Agilent Technologies E8481A 2-Wire 4x32 Relay Matrix Switch Module User’s Manual

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Contents

Agilent E8481A User's Manual

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E8481A 2-Wire 4x32 Relay Matrix Switch Module User's Manual
Edition 1

Documentation History

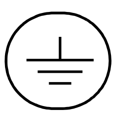
All Editions and Updates of this manual and their creation date are listed below. The first Edition of the manual is Edition 1. The Edition number increments by 1 whenever the manual is revised. Updates, which are issued between Editions, contain replacement pages to correct or add additional information to the current Edition of the manual. Whenever a new Edition is created, it will contain all of the Update information for the previous Edition. Each new Edition or Update also includes a revised copy of this documentation history page.

Edition 1 . . . . March, 2001

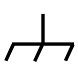
Edition 1, Rev. 1 . . . . September, 2012

Safety Symbols

Instruction manual symbol affixed to product. Indicates that the user must refer to the manual for specific WARNING or CAUTION information to avoid personal injury or damage to the product.



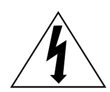
Indicates the field wiring terminal that must be connected to earth ground before operating the equipment — protects against electrical shock in case of fault.

 or 

Frame or chassis ground terminal—typically connects to the equipment's metal frame.

Alternating current (AC)

Direct current (DC).



Warning. Risk of electrical shock.

WARNING Calls attention to a procedure, practice, or condition that could cause bodily injury or death.

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- Alternately, you can go to the product web page (www.agilent.com/find/E8481A), click on the Document Library tab then scroll down until you find the Declaration of Conformity link.

Notes:

Chapter 1
Getting Started

About This Chapter

This chapter describes the Agilent E8481A 2-wire 4x32 Matrix module, contains information on how to program it using SCPI (Standard Commands for Programmable Instruments) commands, and provides an example program to check initial operation. Chapter contents are:

Agilent E8481A Module Description

The Agilent E8481A 4x32 2-wire Matrix Switch module is a VXIbus C-Size register-based product which can operate in a C-Size VXIbus mainframe. It offers highly flexible switching for testing devices, allowing multiple test instruments connected to multiple test points on a device or to multiple devices. It is ideal for switching signals to the oscilloscopes, counters and signal sources in the test systems.

To improve the switching throughput, an 8 kB non-volatile RAM (NVRAM) is provided on the module, allowing to store up to 511 state patterns for all 128 channels of the module. See Page 107 of this manual for more information on the module's NVRAM and state patterns structure.

In addition to a single 2-wire 4x32 matrix, the E8481A can be easily reconfigured as two independent 2-wire 4x16 matrixes. See "Function Modes" on page 12 for more information.

Simplified Schematic

As shown in Figure 1-1, two 2-wire 4x16 matrixes (Group A & Group B) are implemented on the E8481A module PC board which contains 128 2-wire nodes or crosspoints. Each crosspoint in the matrix uses two Form-A non-latching relays to switch both High (H) and Low (L) signals. By closing or opening the appropriate channel relays, the row is connected to or disconnected from the column. Multiple switch relays can be closed at a time, allowing any combination of rows connected to columns.

Since the relays are nonlatching, the channel relays are all open during power-up, power-down, or following a reset.

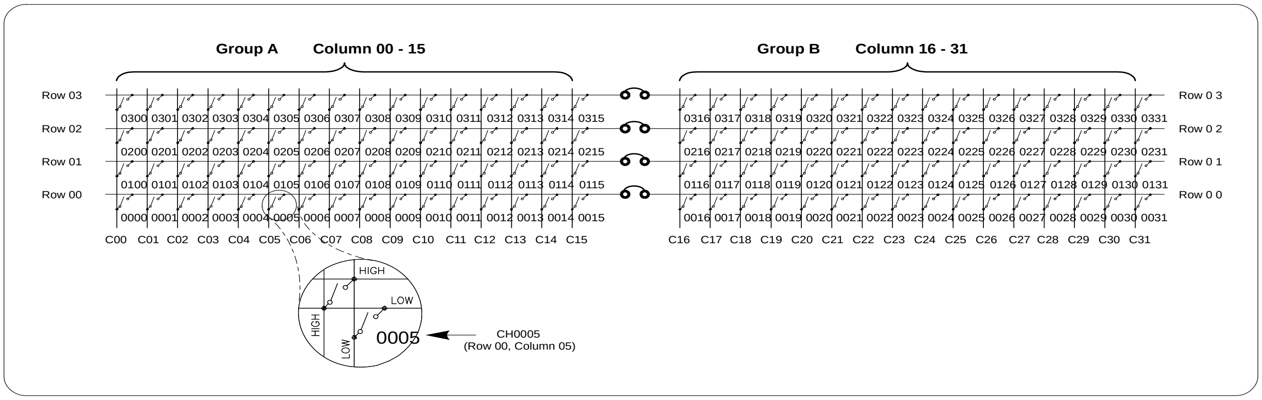


Figure 1-1. Agilent E8481A Simplified Schematic

Function Modes

When shipped from the factory, the E8481A is configured as a 4x32 2-wire Matrix Switch module. All columns (00-31) are switched to rows (00-03) of Group A with 50 MHz bandwidth. By disconnecting the rows of the Group A and the Group B with SCPI command ([ROUTe:]FUNCtion), the module can be reconfigured as two independent 4x16 matrixes. In such case, columns 00-15 are switched to rows 00-03 of Group A, and columns 16-31 are switched to rows 00-03 of Group B with bandwidth up to 70 MHz.

For more information about the related SCPI commands, see “[ROUTe:]FUNCtion” on page 72 of this manual. You can also change the function mode by directly writing to the NVRAM Data Register of the module, see “Setting Module Function Mode” on page 109 of this manual for details.

NOTE *At power up/down or reset, the module will not change the function mode set for it, unless another* [ROUTe:]FUNCtion *command is executed to change the mode.*

NOTE *DO NOT make connections on the rows 00-03 connectors of Group B when in the 4x32 configuration. These connectors are used only when in the Dual 4x16 configuration.*

Typical Configuration

For a Standard Commands for Programmable Instruments (SCPI) environment, one or more E8481A modules can be configured as a switchbox instrument. For a switchbox instrument, all modules within the instrument can be addressed using a single interface address.

Instrument Definition

The plug-in modules installed in an Agilent mainframe or used with an Agilent command module are treated as independent instruments, each having a unique secondary GPIB address. Each instrument is also assigned a dedicated error queue, input and output buffers, status registers and, if applicable, dedicated mainframe/command module memory space for readings or data. An instrument may be composed of a single plug-in module (such as a counter) or multiple plug-in modules (for a switchbox or scanning multimeter instrument).

Programming the Module

To program the module using SCPI commands, you must select the controller language, interface address, and SCPI commands to be used. See the *C-Size VXIbus System Configuration Guide* for detailed interface addressing and controller language information. For uses in other systems or mainframes, see the appropriate manuals. For more details of SCPI commands applicable to the module, refer to Chapter 4 of this manual.

NOTE *This section only discusses SCPI programming. The module can also be programmed by writing directly to its registers. See Appendix B for details on register programming.*

Specifying SCPI Commands

To address specific channels within an E8481A module, you must specify the appropriate SCPI command and matrix channel addresses. Table 1-1 lists the most commonly used commands. Refer to Chapter 4 of this manual for a complete list of SCPI commands used for the matrix switch module.

Table 1-1. Commonly Used SCPI Commands

SCPI Commands	Commands Description
CLOSe <*channel_list*>	Closes the relay(s) specified.
OPEN <*channel_list*>	Opens the relay(s) specified.
SCAN <*channel_list*>	Closes a set of relays, one at a time.

Channel Addresses

Only valid channel addresses can be included in a *channel_list*. For the E8481A, the channel address has the form of (@*ssrrcc*) where

ss = card number (01-99)
rr = row number of the matrix (00-03)
cc = column number of the matrix (00-31)

To specify a *channel_list*, use the form of:

- (@ssrrcc) for a single channel
- (@ssrrcc,ssrrcc,...) for multiple channels

- (@ssrrcc:ssrrcc) for sequential channels
- (@ssrrcc:ssrrcc,ssrrcc:ssrrcc) for groups of sequential channels
- or any combination of the above.

NOTE *Only valid channels can be accessed in a channel list or channel range. Channel numbers can be entered in the channel_list in any random order. However, the channel range must be from a lower channel number to a higher channel number. For example, CLOS (@10000:10312) is acceptable, but CLOS (@10312:10000) generates an error.*

Card Number

The card number (*ss* of the *channel_list*) identifies which module within a switchbox will be addressed. The card number assigned depends on the switch configuration used. Leading zeroes can be ignored for the card number.

- **Single-module Switchbox**. In a single-module switchbox configuration, the card number is always 01.

- **Multiple-module Switchbox**. In a multiple-module switchbox configuration, modules are set to successive logical addresses. The module with the lowest logical address is always card number 01. The module with the next successive logical address is card number 02, and so on. Figure 1-2 illustrates the card numbers and logical addresses of a typical multiple-module switchbox installed in an Agilent C-Size mainframe with an Agilent command module.

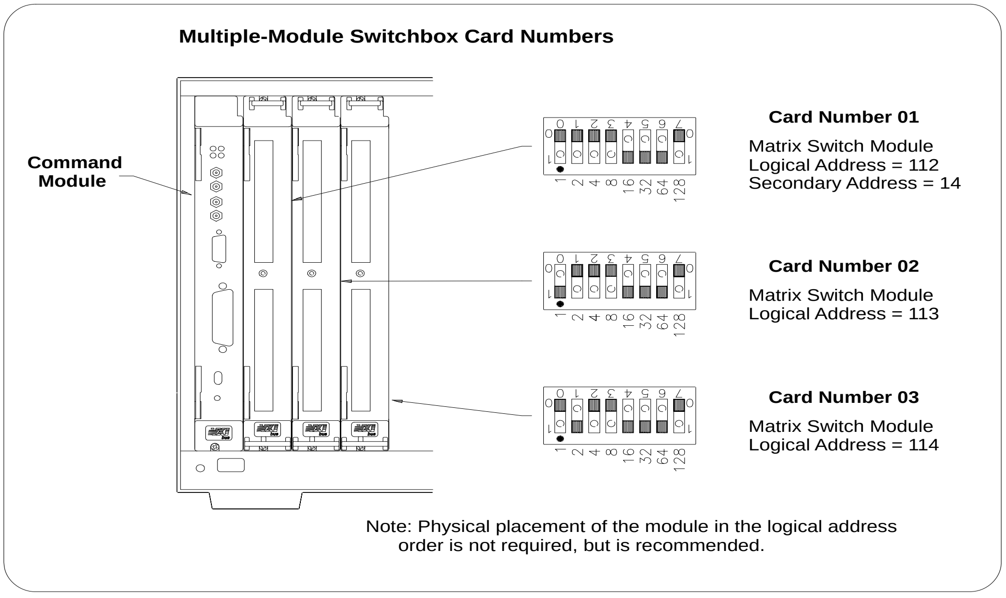


Figure 1-2. Card Numbers in a Multiple-modules Switchbox

Channel Number

The channel number (*rrcc* of the *channel_list*) identifies which relay on the selected module will be addressed. The channel numbers are:

row number: *rr* = 00 - 03 (two digits)
column number: *cc* = 00 - 31 (two digits)

For example, CLOS (@10214) will close channel relays on row 02, column 14 of an E8481A module.

Initial Operation

Use the following example programs to perform the initial operation on the E8481A module. To run the programs, an Agilent E1406A command module is required. Also, you must download the E8481A SCPI driver into the E1406A command module and have the Agilent SICL Library, the VISA extensions, and an Agilent 82350 GPIB card installed and properly configured in your PC.

In the examples, the computer interfaces to the mainframe via GPIB. The GPIB interface select code is 7, the GPIB primary address is 09, and the E8481A module is at logical address 112 (secondary address = 112/8 = 14). Refer to the *Agilent E1406A Command Module User's Guide* for more addressing information. For more details on the related SCPI commands used in the examples, see Chapter 4 of this manual.

Example: Closing a Channel (HTBasic)

This example program was written in HTBasic programming language. The program closes channel 0002, then queries its state. The result is returned to the computer and displayed ("1" = channel closed, "0" = channel open).

```
10   DIM Ch_Stat$[20]                      ! Dimension a variable.
20   OUTPUT 70914; "*RST"                  ! Resets the module.
30   OUTPUT 70914; "CLOS (@10002)"         ! Close channel 10002.
40   OUTPUT 70914; "CLOS? (@10002)"        ! Query channel 10002 closed
                                             state.
50   ENTER 70914;Ch_Stat$                  ! Enter results into Ch_stat$.
60   PRINT Ch_Stat$                        ! Display results, "1" should be
                                             returned.
70   END
```

Example: Closing a Channel (C/C++)

This example program was developed and tested in Microsoft® Visual C++ 6.0 but should compile under any standard ANSI C compiler. The program closes channel 0002, then queries its state. The result is returned to the computer and displayed ("1" = channel closed, "0" = channel open).

```
#include <visa.h>
#include <stdio.h>
#include <stdlib.h>

    /* Module logical address is 112, secondary address is 14 */
#define INSTR_ADDR "GPIB0::9::14::INSTR"
```

```
int main()
{
    ViStatus errStatus;                    /* Status from each VISA call */
    ViSession viRM;                        /* Resource manager session */
    ViSession E8481A;                      /* Module session */
    char state[10];                        /* Channel state */

    /* Open the default resource manager */
    errStatus = viOpenDefaultRM (&viRM);
    if(VI_SUCCESS > errStatus){
        printf("ERROR: viOpenDefaultRM() returned 0x%x\n", errStatus);
        return errStatus;}

    /* Open the module instrument session */
    errStatus = viOpen(viRM,INSTR_ADDR, VI_NULL,VI_NULL,&E8481A);
    if(VI_SUCCESS > errStatus){
        printf("ERROR: viOpen() returned 0x%x\n", errStatus);
        return errStatus;}

    /* Reset the module */
    errStatus = viPrintf(E8481A, "*RST;*CLS\n");
    if(VI_SUCCESS > errStatus){
        printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
        return errStatus;}

    /* Close channel 0002 */
    errStatus = viPrintf(E8481A, "CLOS (@10002)\n");
    if(VI_SUCCESS > errStatus){
        printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
        return errStatus;}

    /* Query state of channel 0002 */
    errStatus = viQueryf(E8481A, "ROUT:CLOS? (@10002)\n", "%t",state);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viQueryf() returned 0x%x\n", errStatus);
        return errStatus;}
    printf("Channel State is: %s\n",state);

    /* Close the module instrument session */
    errStatus = viClose (E8481A);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viClose() returned 0x%x\n", errStatus);
        return 0;}

    /* Close the resource manager session */
    errStatus = viClose (viRM);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viClose() returned 0x%x\n", errStatus);
        return 0;}

    return VI_SUCCESS;
}
```

Chapter 2

Configuring the Module

About This Chapter

This chapter shows how to configure the Matrix Switch module for use in a VXIbus mainframe, install it in a mainframe, and connect external wiring to the matrix module. Chapter contents include:

Warnings and Cautions

WARNING **SHOCK HAZARD. Only qualified, service-trained personnel who are aware of the hazards involved should install, configure, or remove the Matrix switch module. Remove all power sources from the mainframe and installed modules before installing or removing a module.**

Caution **MAXIMUM INPUTS. The maximum voltage that can be applied to any terminal is 42 Vdc or 30 V ac rms. The maximum current that can be applied to any terminal is 0.5 A dc or ac peak. The maximum power that can be applied to any terminal is 5 W or 5 VA (resistive). Exceeding any limit may damage the Matrix Switch module.**

STATIC ELECTRICITY. Static electricity is a major cause of component failure. To prevent damage to the electrical components in the matrix module, observe anti-static techniques whenever removing or installing a module or whenever working on a module.

Setting the Logical Address

The logical address switch (LADDR) factory setting is 112. Valid address values are from 1 to 255. Refer to Figure 2-1 for the address switch position and setting information.

NOTE *The address switch selected value must be a multiple of 8 if the module is the first module in a switchbox used with a VXIbus command module, and being instructed by SCPI commands.*

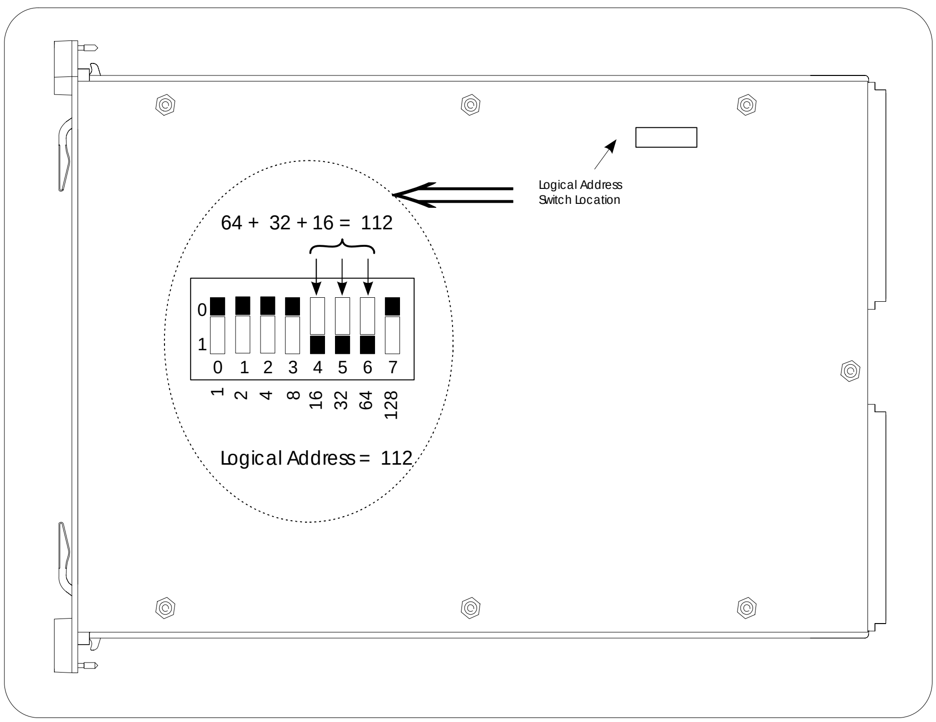


Figure 2-1. Setting the Logical Address Switch

Setting the Interrupt Priority

The E8481A module generates an interrupt after a channel has been closed. These interrupts are sent to, and acknowledgments are received from, the command module (Agilent E1406A) via the VXIbus backplane interrupt lines.

For most applications the default interrupt priority line should not have to be changed. This is because the VXIbus interrupt lines have the same priority and interrupt priority is established by installing modules in slots numerically closest to the command module. Thus, slot 1 has a higher priority than slot 2, slot 2 has a higher priority than slot 3, etc.

By default, the interrupt priority level is Level 1. It can be set to any one of the VXI backplane lines 1-7 (corresponding to Levels 1-7) either by sending SCPI or directly writing to the Interrupt Selection Register. Level 1 is the lowest priority and Level 7 is the highest priority. The interrupt can also be disabled at power-up, after a SYSRESET, or by sending SCPI or directly writing to the Status/Control Register. See Page 59 of this manual for more details of the related SCPI commands. For more information about register writing, see "Register-Based Programming" on page 97 of this manual.

NOTE *Changing the interrupt priority level is not recommended. DO NOT change it unless specially instructed to do so. Refer to the E1406A Command Module User's Manual for more details.*

Installing the Matrix Switch Module in a Mainframe

The Agilent E8481A may be installed in any slot (except slot 0) in a C-size VXIbus mainframe. Refer to Figure 2-2 to install the module in a mainframe.

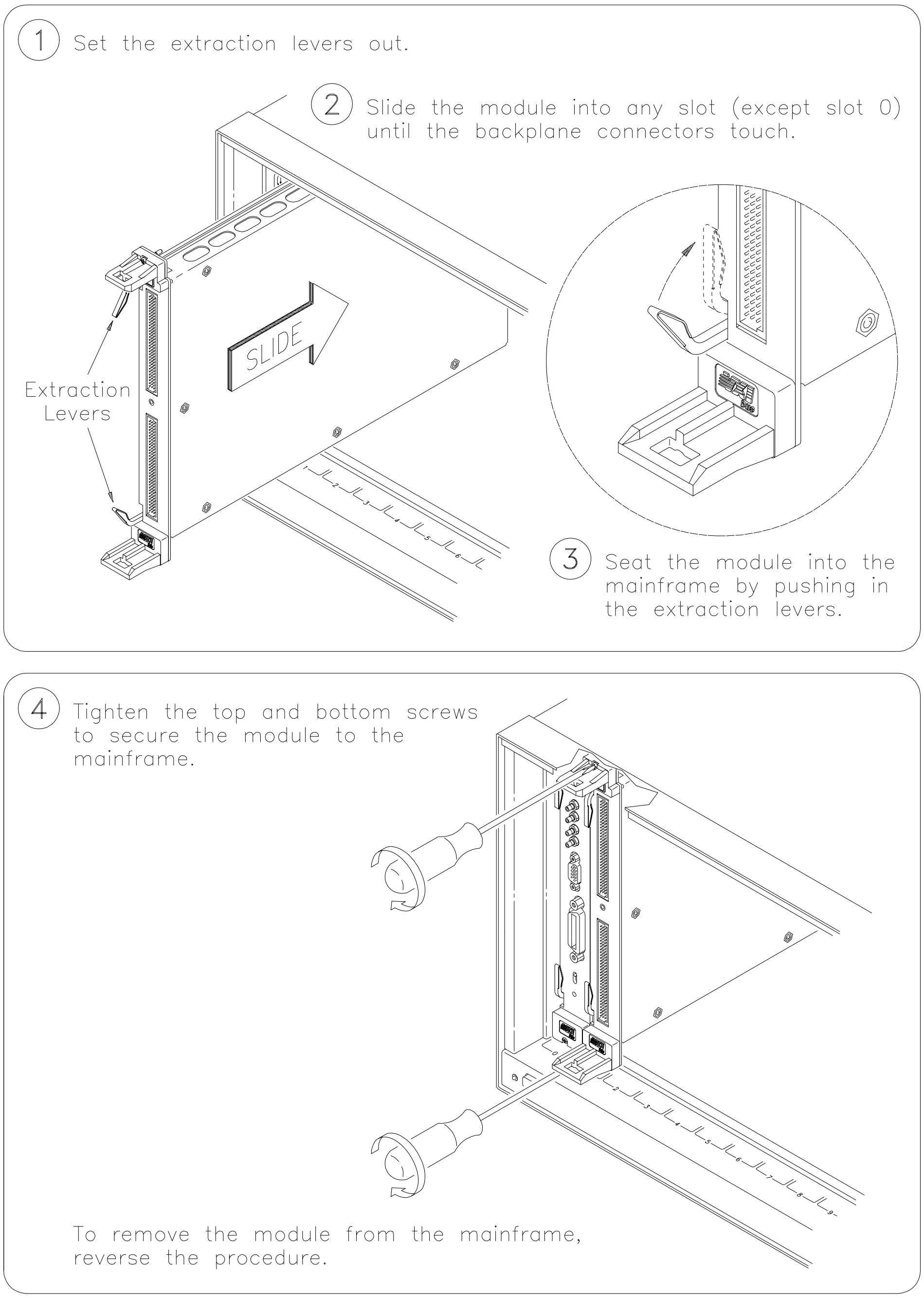


Figure 2-2. Installing the Matrix Switch Module in a VXIbus Mainframe

Connecting User Inputs

The Agilent E8481A Matrix Switch module is not supplied with terminal modules which must be ordered separately. Two types of terminal modules are available for the Agilent E8481A Matrix Switch module. Order Option 106 if a screw type terminal module is desired. If an SMB terminal module is desired, order Option 105. User inputs to the matrix switch module are made via the Row and Column terminal connectors on these terminal modules. The following sections provide the detailed information on the module's connectors pinout, the screw type terminal module and the SMB terminal module, as well as on how to connect field wiring to the terminal module.

Connectors Pinout

Figure 2-3 shows the front panel of the Agilent E8481A and the connectors pinout which mates to the terminal module.

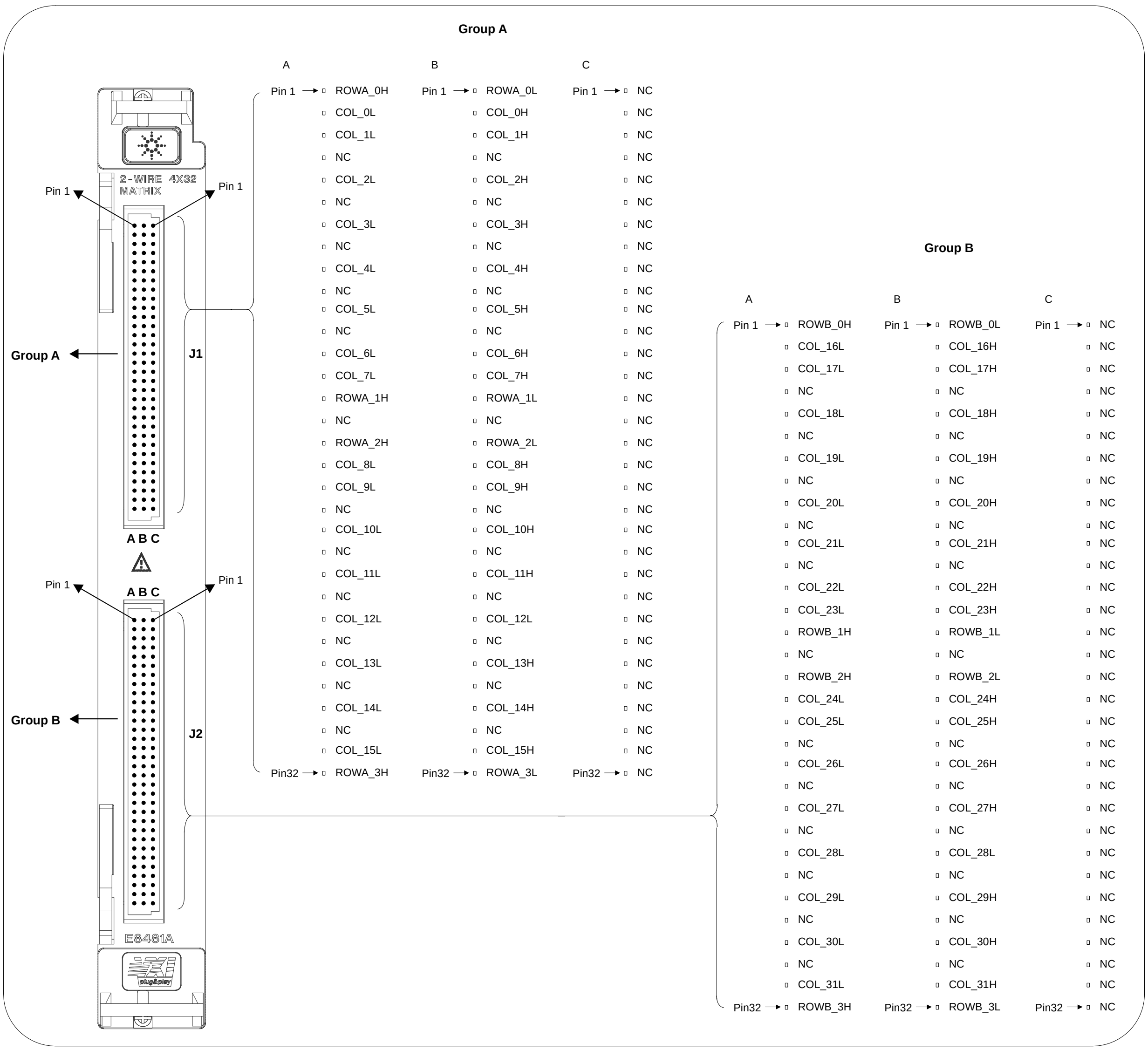


Figure 2-3. Agilent E8481A Matrix Switch Connectors Pinout

Screw Type Terminal Module

Figure 2-4 shows the Option 106 screw type terminal module connectors and associated row/column designators.

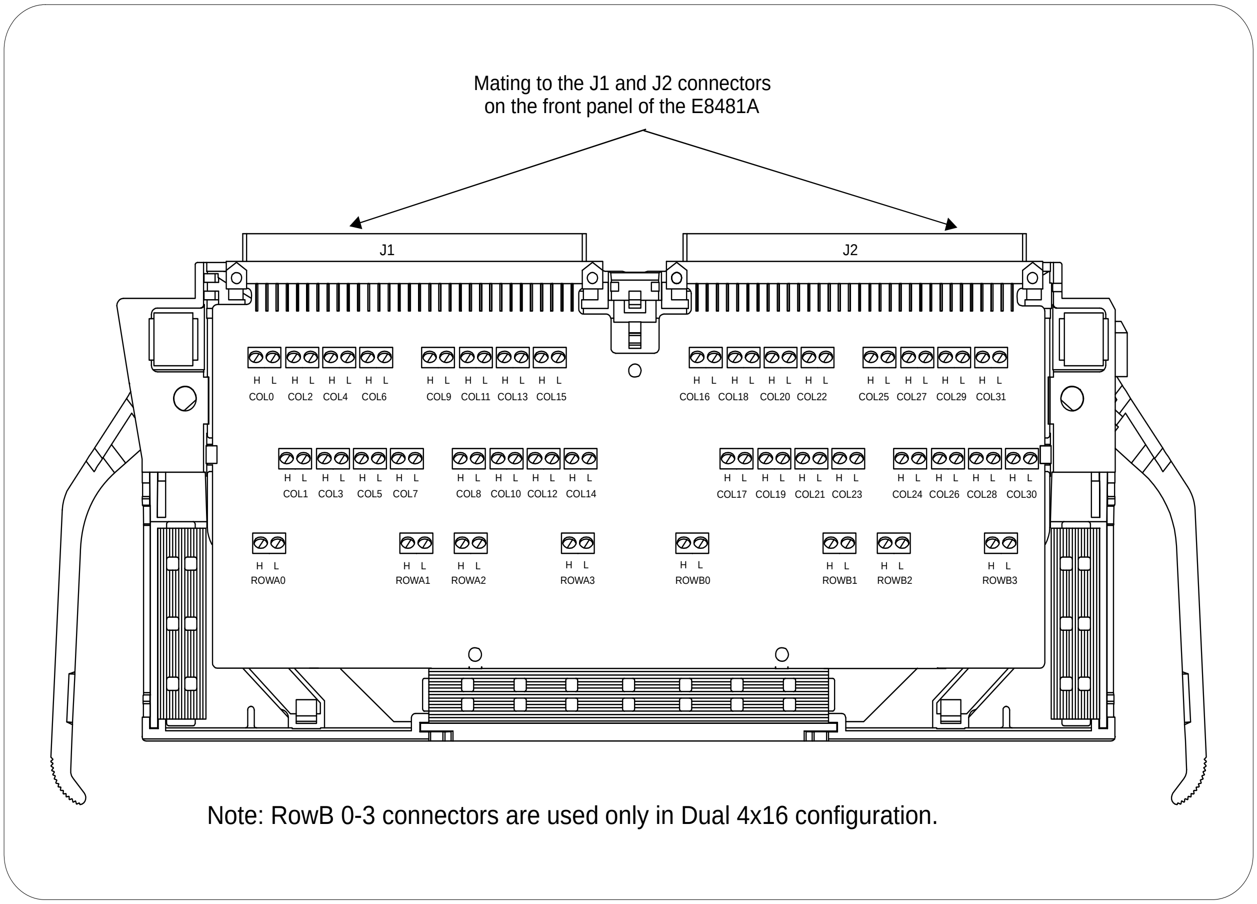


Figure 2-4. Screw Type Terminal Module

SMB Type Terminal Module

Figure 2-5 shows the Option 105 SMB type terminal module connectors and associated row/column designators. This SMB terminal module provides a convenient way to connect the field wiring to the matrix switch module via SMB cables.

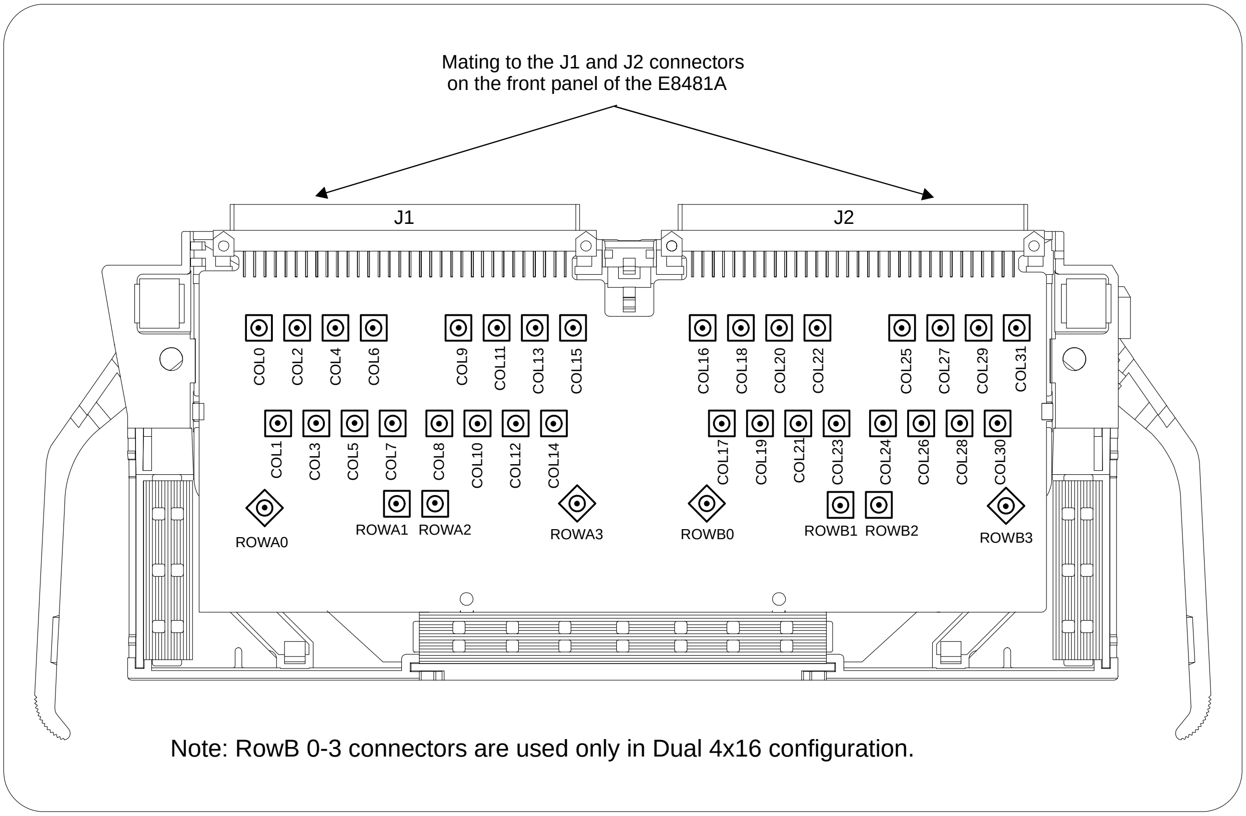


Figure 2-5. SMB Terminal Module

Wiring a Terminal Module

The following illustrations show how to connect field wiring to the screw type or SMB type terminal module, and how to attach the terminal module to the relay matrix switch module.

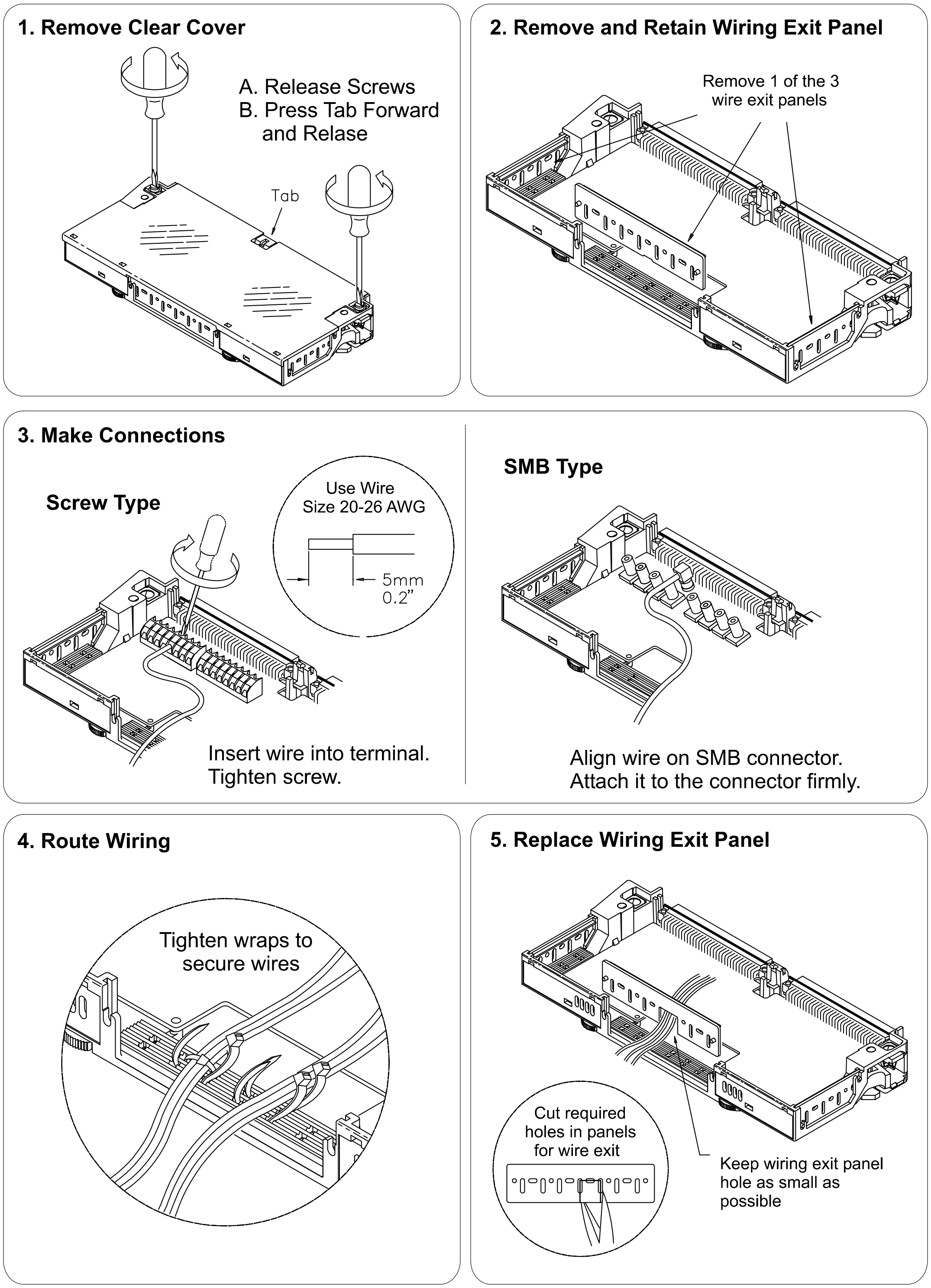
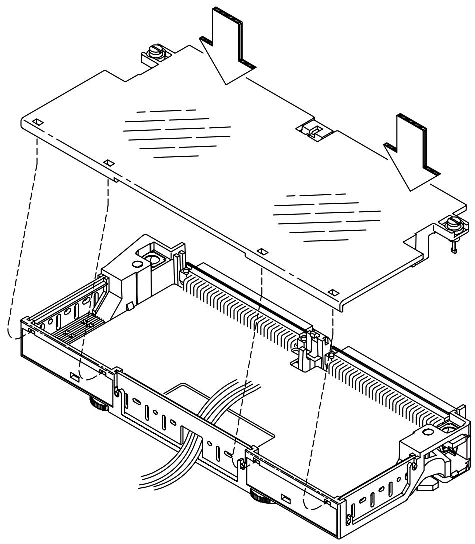


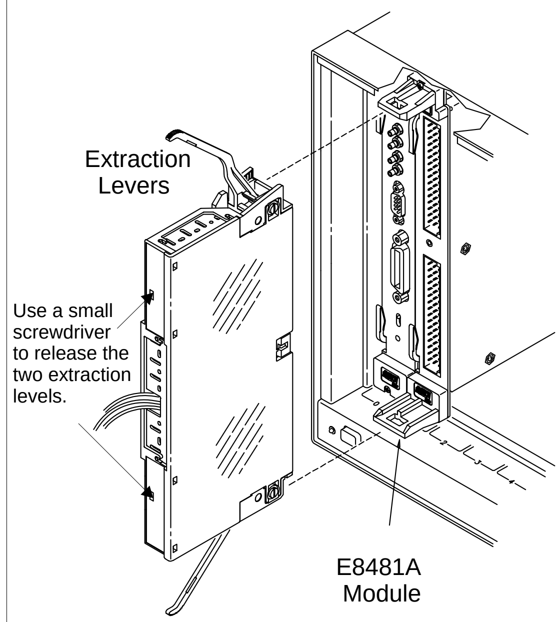
Figure 2-6. Wiring a Terminal Module (*continued on next page*)

6. Replace Clear Cover

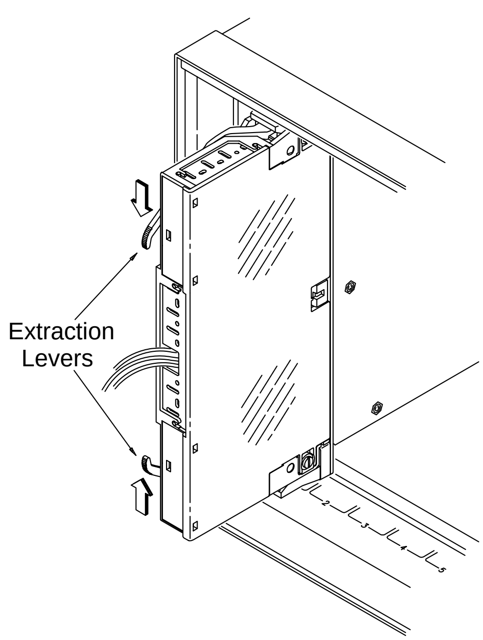


A. Hook in the top cover tabs onto the fixture.
B. Press down and tighten screws.

7. Attach the Terminal Module to the Matrix (see Figure 2-7 for more information)



9. Push in the Extraction Levers to Lock the Terminal Module onto the Matrix Module



Notes:

* Be sure the wires make good connections on the terminal modules.

* DO NOT make connections on the RowB_0 through RowB_3 connectors when in 4x32 mode.

* To remove the terminal module from the E8481A, use a small screwdriver to release the two extraction levels and push both evels out simultaneously to free it from the E8481A Matrix Module.

Figure 2-6. Wiring a Terminal Module

Attaching a Terminal Module to the Matrix Module

Figure 2-7 shows how to attach a terminal module to the E8481A Relay Matrix Switch module.

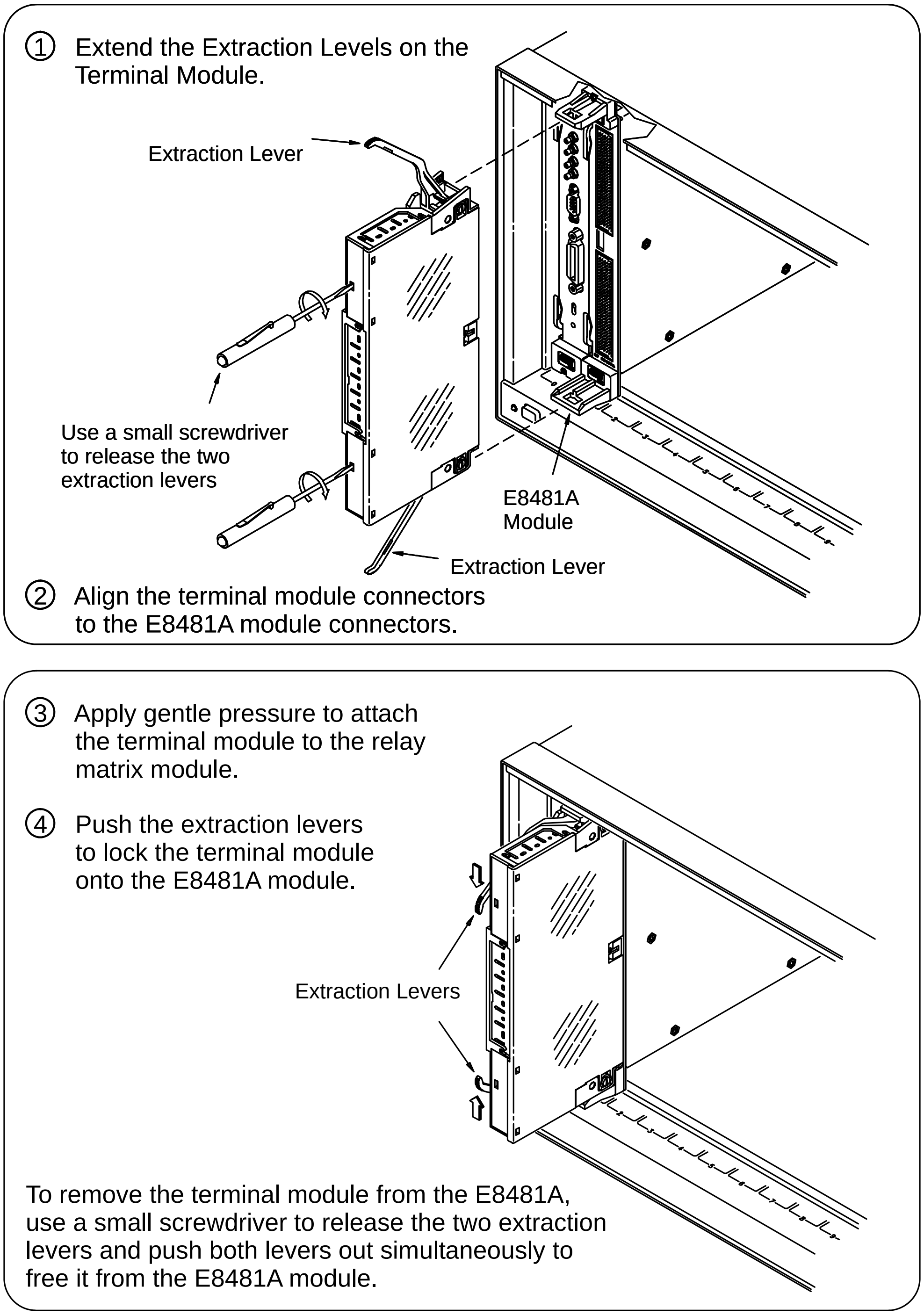


Figure 2-7. Attach a Terminal Module to the E8481 Matrix Module

Chapter 3

Using the Matrix Module

About This Chapter

This chapter uses typical examples to show how to use the E8481A Matrix module. Chapter contents are:

All example programs in this chapter were developed on an external PC using HTBasic or Visual C/C++ as the programming language. They are tested with the following system configuration:

- An E1406A command module and an E8481A Matrix module are installed in the mainframe.
- The computer is connected to the E1406A command module via GPIB interface. The GPIB select code is 7, the GPIB primary address is 09, and the E8481A module is at logical address 112 (secondary address = 112/8 = 14).
- The E8481A SCPI driver had been downloaded into the E1406A command module.
- The SICL Library, the VISA extensions, and an Agilent 82350 GPIB card had been installed and properly configured in the computer.

Refer to the *Agilent E1406A Command Module User's Guide* for more addressing information. For more details on the related SCPI commands used in this chapter, see Chapter 4 of this manual.

NOTE *Do not do register writes if you are controlling the module by a high level driver such as SCPI or VXIplug&play. This is because the driver will not know the module state and an interrupt may occur causing the driver and/or command module to fail.*

Power-On and Reset Conditions

At power-on or following a reset (*RST command), all channels of the module are open. The *RST command also invalidates the current scan list (that is, you must specify a new scan list for scanning). Command parameters are set to the default conditions as shown below.

Table 3-1. E8481A Default Conditions for Power-on and Reset

Parameter	Default	Description
ARM:COUNt	1	Number of scanning cycles is 1.
TRIGger:SOURce	IMM	Advances through a scanning list automatically.
INITiate:CONTinuous	OFF	Continuous scanning is disabled.
OUTPut:ECLTrg*n*[:STATe]	OFF	Trigger output from ECL trigger line is disabled.
OUTPut[:EXTernal][:STATe]	OFF	Trigger output from "Trig Out" port is disabled.
OUTPut:TTLTrg*n*[:STATe]	OFF	Trigger output from TTL trigger line is disabled.

Module Identification

The following example programs use the *RST, *CLS, *IDN?, SYST:CTYP?, and SYST:CDES? commands to reset and identify the Matrix module.

Example: Identifying Module (HTBasic)

```
10  DIM A$[50], B$[50], C$[50]        ! Dimension three string
                                      variables to fifty characters.
20  OUTPUT 70914; "*RST; *CLS"        ! Reset the module and clear
                                      status registers.
30  OUTPUT 70914; "*IDN?"             ! Query module identification.
40  ENTER 70914; A$                   ! Enter the result into A$.

50  OUTPUT 70914; "SYST:CDES? 1"      ! Query for module description.
60  ENTER 70914; B$                   ! Enter the result into B$.

70  OUTPUT 70914; "SYST:CTYP? 1"      ! Query for module type.
80  ENTER 70914; C$                   ! Enter the result into C$.

90  PRINT A$, B$, C$                  ! Print the contents of the
                                      variable A$, B$ and C$.
100 END
```

Example: Identifying Module (C/C++)

```
#include <visa.h>
#include <stdio.h>
#include <stdlib.h>

    /* Module logical address is 112, secondary address is 14 */
#define INSTR_ADDR "GPIB0::9::14::INSTR"

int main()
{
    ViStatus errStatus;                 /* Status from each VISA call */
    ViSession viRM;                     /* Resource manager session */
    ViSession E8481A;                   /* Module session */

    char id_string[256];                /* ID string */
    char m_desp[256];                   /* Module description */
    char m_type[256];                   /* Module type */

    /* Open the default resource manager */
    errStatus = viOpenDefaultRM (&viRM);
    if(VI_SUCCESS > errStatus){
        printf("ERROR: viOpenDefaultRM() returned 0x%x\n", errStatus);
        return errStatus;}

    /* Open the module instrument session */
    errStatus = viOpen(viRM,INSTR_ADDR, VI_NULL,VI_NULL,&E8481A);
    if(VI_SUCCESS > errStatus){
        printf("ERROR: viOpen() returned 0x%x\n", errStatus);
        return errStatus;}

    /* Reset the matrix module and clear the status registers */
    errStatus = viPrintf(E8481A, "*RST;*CLS\n");
    if(VI_SUCCESS > errStatus){
        printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
        return errStatus;}

    /* Query the module ID string */
    errStatus = viQueryf(E8481A, "*IDN?\n", "%t", id_string);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viQueryf() returned 0x%x\n", errStatus);
        return errStatus;}
    printf("ID is %s\n", id_string);

    /* Query the module description */
    errStatus = viQueryf(E8481A, "SYST:CDES? 1\n", "%t", m_desp);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viQueryf() returned 0x%x\n", errStatus);
        return errStatus;}
    printf("Module Description is %s\n", m_desp);
```

```
    /* Query the module type */
    errStatus = viQueryf(E8481A, "SYST:CTYP? 1\n", "%t", m_type);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viQueryf() returned 0x%x\n", errStatus);
        return errStatus;}
    printf("Module Type is %s\n", m_type);

    /* Close the module instrument session */
    errStatus = viClose (E8481A);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viClose() returned 0x%x\n", errStatus);
        return 0;}

    /* Close the resource manager session */
    errStatus = viClose (viRM);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viClose() returned 0x%x\n", errStatus);
        return 0;}

    return VI_SUCCESS;
}
```

Setting Module Function Mode

When shipped from the factory, the E8481A is configured as a 4x32 matrix module. The E8481A matrix module can also be set to function as two independent 4x16 matrixes. Use the FUNC *<card_num>, <mode>* command to set the module to the desired function mode.

The following example programs were written in HTBasic and Visual C/C++ programming languages. They will set the E8481A to function as two independent 4x16 matrixes, then query the setting. The result is returned to the computer and displayed ("SINGLE4X32" indicates the module functioned as a 4x32 Matrix, "DUAL4X16" indicates the module functioned as two independent 4x16 matrixes).

Example: Setting Function Mode (HTBasic)

```
10   DIM Func$[20]                          ! Dimension a string variable
                                              to twenty characters.
20   OUTPUT 70914; "*RST; *CLS"             ! Reset the module and clear
                                              status registers.

30   OUTPUT 70914; "ROUT:FUNC 1, DUAL4X16"
                                            ! Set the module as dual 4x16
                                              matrixes.

40   OUTPUT 70914; "ROUT:FUNC? 1"           ! Query the function mode.
50   ENTER 70914; Func$                     ! Enter the result into Func$.
60   PRINT A$                               ! "DUAL4X16" will be
                                              displayed.
70   END
```

Example: Setting Function Mode (C/C++)

```
#include <visa.h>
#include <stdio.h>
#include <stdlib.h>

    /* Module logical address is 112, secondary address is 14 */
#define INSTR_ADDR "GPIB0::9::14::INSTR"

int main()
{
   ViStatus errStatus;                 /* Status from each VISA call */
   ViSession viRM;                     /* Resource manager session */
   ViSession E8481A;                   /* Module session */
   char func[20];                      /* Function mode */

    /* Open the default resource manager */
   errStatus = viOpenDefaultRM (&viRM);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpenDefaultRM() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Open the module instrument session */
   errStatus = viOpen(viRM,INSTR_ADDR, VI_NULL,VI_NULL,&E8481A);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpen() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Reset the module */
   errStatus = viPrintf(E8481A, "*RST;*CLS\n");
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Set module to function as dual 4x16 matrixes */
   errStatus = viPrintf(E8481A, "ROUT:FUNC 1, DUAL4X16\n");
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Query the function mode set for the module */
   errStatus = viQueryf(E8481A, "ROUT:FUNC? 1\n", "%t", func);
   if (VI_SUCCESS > errStatus) {
      printf("ERROR: viQueryf() returned 0x%x\n", errStatus);
      return errStatus;}
   printf("The module is set to function as: %s\n", func);

    /* Close the module instrument session */
   errStatus = viClose (E8481A);
   if (VI_SUCCESS > errStatus) {
      printf("ERROR: viClose() returned 0x%x\n", errStatus);
      return 0;}
```

```
    /* Close the resource manager session */
    errStatus = viClose (viRM);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viClose() returned 0x%x\n", errStatus);
        return 0;}

    return VI_SUCCESS;
}
```

Switching Channels

Use CLOSe <*channel_list*> to close one or more matrix channels, and use OPEN <*channel_list*> to open the channel(s). The *channel_list* has the form:

- (@ssrrcc) for a single channel
- (@ssrrcc,ssrrcc) for multiple channels
- (@ssrrcc:ssrrcc) for sequential channels
- (@ssrrcc:ssrrcc,ssrrcc:ssrrcc) for groups of sequential channels
- or any combination of the above.

where ss = card number (01-99), rr = row number (00-03) and cc = column number (00-31).

The following example programs were written in HTBasic and Visual C/C++ programming languages. They will show how to close/open channels, then query their state. The result is returned to the computer and displayed (1 = channel closed, 0 = channel open).

Example: Closing Multiple Channels (HTBasic)

```
10  DIM A$[20]                          ! Dimension a string variable to
                                          twenty characters.
20  OUTPUT 70914; "*RST; *CLS"          ! Reset the module and clear
                                          status registers.

30  OUTPUT 70914; "ROUT:CLOS (@10003, 10102)"
                                        ! Close channels 10003
                                          and 10102.
40  OUTPUT 70914; "ROUT:OPEN (@10003)"
                                        ! Open channel 10003.

50  OUTPUT 70914; "ROUT:CLOS? (@10003, 10102)"
                                        ! Query closure state of channels
                                          10003 and 10102.

60  ENTER 70914; A$                     ! Enter the result into A$.
70  PRINT A$                            ! "0,1" will be displayed.
80  END
```

Example: Closing Multiple Channels (C/C++)

```
#include <visa.h>
#include <stdio.h>
#include <stdlib.h>

    /* Module logical address is 112, secondary address is 14 */
#define INSTR_ADDR "GPIB0::9::14::INSTR"

int main()
{
   ViStatus errStatus;                /* Status from each VISA call */
   ViSession viRM;                    /* Resource manager session */
   ViSession E8481A;                  /* Module session */
   char ch_stat[10];                  /* Channel state */

    /* Open the default resource manager */
   errStatus = viOpenDefaultRM (&viRM);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpenDefaultRM() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Open the module instrument session */
   errStatus = viOpen(viRM,INSTR_ADDR, VI_NULL,VI_NULL,&E8481A);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpen() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Reset the module */
   errStatus = viPrintf(E8481A, "*RST;*CLS\n");
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Query closure state of channel 0002 after a reset */
   errStatus = viQueryf(E8481A,"ROUT:CLOS? (@10002)\n","%t",ch_stat);
   if (VI_SUCCESS > errStatus) {
      printf("ERROR: viQueryf() returned 0x%x\n", errStatus);
      return errStatus;}
   printf("After reset, chan 10002 state is: %s\n", ch_stat);

    /* Close channel 0002 of card 1*/
   errStatus = viPrintf(E8481A, "CLOS (@10002)\n");
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Query closure state of channel 0002 */
   errStatus = viQueryf(E8481A,"ROUT:CLOS? (@10002)\n","%t",ch_stat);
   if (VI_SUCCESS > errStatus) {
      printf("ERROR: viQueryf() returned 0x%x\n", errStatus);
      return errStatus;}
   printf("Now, channel 10002 state is: %s\n", ch_stat);
```

```
    /* Close the module instrument session */
    errStatus = viClose (E8481A);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viClose() returned 0x%x\n", errStatus);
        return 0;}

    /* Close the resource manager session */
    errStatus = viClose (viRM);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viClose() returned 0x%x\n", errStatus);
        return 0;}

    return VI_SUCCESS;
}
```

Using State Patterns to Switch Channels

To improve the switching throughput, an 8 kB non-volatile RAM (NVRAM) is provided on the module, allowing to store up to 511 state patterns for all 128 channels. Then you can operate the channel relays with the stored pattern whenever you required. In this way, switching all 128 channels is almost as fast as switching a single channel.

The following example programs were written in HTBasic and Visual C/C++ languages, respectively. Each uses a state pattern to operate the channel relays. They first reset the module to open all channels of the module, then set channels state in a pattern (including select a pattern number, open all channels in the pattern, then close some of the channels in the pattern). After having finished the pattern setting, you can use the saved pattern to operate the channels whenever you require.

For the related SCPI commands used in these examples, see [ROUTe:]PATTern: subsystem on Page 74 of this manual. If you want to learn more about the pattern structure in the NVRAM, see “NVRAM Control Registers” on page 107 of this manual.

NOTE *Before setting/querying channels open/closed state in a pattern, you must use* PATT:NUMB *command to select a pattern first.*

Example: Using a State Pattern to Switch Channels (HTBasic)

```
10  DIM Ch_PatStat$[50],Ch_Stat$[50],Err_num$[256]
                                        ! Dimension three string
                                          variables.
20  OUTPUT 70914; "*RST;*CLS"           ! Reset the module and clear
                                          Status registers.
30  OUTPUT 70914; "PATT:NUMB 1,10"      ! Select pattern 10 of module #1.

40  OUTPUT 70914; "PATT:OPEN (@10000:10331)"
                                        ! Set all 128 channels in pattern
                                          10 to the open state.
```

```
50   OUTPUT 70914; "PATT:CLOS (@10000,10101,10202)"
                                             ! Set channels 10000, 10101 and
                                               10202 to the closure state in
                                               pattern 10.
60   OUTPUT 70914; "PATT:CLOS? (@10000,10101,10202)"
                                             ! Query to verify the settings in
                                               pattern 10.

70   ENTER 70914; Ch_PatStat$                ! Enter the result into the
                                               variable.
80   PRINT "The channel states in Pattern 10: ";Ch_PatStat$
                                             ! "1,1,1" should be displayed.
90   OUTPUT 70914; "ROUT:CLOS? (@10000,10101,10202)"
                                             ! Query to verify the actual state
                                               of these channels.
100 ENTER 70914; Ch_Stat$                    ! Enter the result into Ch_Stat$.

110 PRINT "Channel States: ";Ch_Stat$        ! "0,0,0" should be displayed.

120 OUTPUT 70914; "PATT:ACT 1,10"            ! Recall pattern 10 to operate all
                                               channels of module #1.
130 OUTPUT 70914; "ROUT:CLOS? (@10000,10101,10202)"
                                             ! Query to verify the closure
                                               state of these channels.
140 ENTER 70914; Ch_Stat$                    ! Enter the result into the
                                               variable.
150 PRINT "Channel States: ";Ch_Stat$        ! "1,1,1" should be displayed.

160 OUTPUT 70914; "SYST:ERR?"                ! Check for a system error.
170 ENTER 70914;Err_num$                     ! Enter the error into Err_num$.
180 PRINT "Error: ";Err_num$                 ! Print error if any.
190 END
```

Example: Using a State Pattern to Switch Channels (C/C++)

```
#include <visa.h>
#include <stdio.h>
#include <stdlib.h>

    /* Module logical address is 112, secondary address is 14 */
#define INSTR_ADDR "GPIB0::9::14::INSTR"

int main()
{
   ViStatus errStatus;                    /* Status from each VISA call */
   ViSession viRM;                        /* Resource manager session */
   ViSession E8481A;                      /* Module session */
   char pstat[256];                       /* Channel state in pattern */
   char cstat[256];                       /* Channel state */

    /* Open the default resource manager */
   errStatus = viOpenDefaultRM (&viRM);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpenDefaultRM() returned 0x%x\n", errStatus);
      return errStatus;}
```

```
/* Open the module instrument session */
errStatus = viOpen(viRM,INSTR_ADDR, VI_NULL,VI_NULL,&E8481A);
if(VI_SUCCESS > errStatus){
    printf("ERROR: viOpen() returned 0x%x\n", errStatus);
    return errStatus;}

/* Reset the module */
errStatus = viPrintf(E8481A, "*RST;*CLS\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

/* Select pattern 10 on module #1 for storing states*/
errStatus = viPrintf(E8481A, "PATT:NUMB 1, 10\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

/* Open all channels in pattern 10 */
errStatus = viPrintf(E8481A, "PATT:OPEN (@10000:10331)\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

/* Close channels 0000, 0101 and 0202 in pattern 10 */
errStatus = viPrintf(E8481A, "PATT:CLOS (@10000,10101,10202)\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

/* Query channels 0000, 0101 and 0202 state in pattern 10 */
errStatus = viQueryf(E8481A, "PATT:CLOS?
            (@10000,10101,10202)\n", "%t", pstat);
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

/* Query the actual states of channels 0000,0101and 0202 */
/* "0,0,0" should be displayed. */
errStatus = viQueryf(E8481A, "ROUT:CLOS?
            (@10000,10101,10202)\n", "%t", cstat);
if (VI_SUCCESS > errStatus) {
    printf("ERROR: viQueryf() returned 0x%x\n", errStatus);
    return errStatus;}
printf("Before recall pattern, channel state is: %s\n", cstat);

/* Recall pattern 10 to operate relays on module #1*/
errStatus = viPrintf(E8481A, "PATT:ACT 1, 10\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}
```

```
    /* Verify whether channels 0000,0101,0202 are really closed */
    /* "1,1,1" should be displayed after recalling the pattern. */
   errStatus = viQueryf(E8481A, "ROUT:CLOS?
               (@10000,10101,10202)\n", "%t", cstat);
   if (VI_SUCCESS > errStatus) {
      printf("ERROR: viQueryf() returned 0x%x\n", errStatus);
      return errStatus;}
   printf("After recall pattern, channel state is: %s\n", cstat);

    /* Close the module instrument session */
   errStatus = viClose (E8481A);
   if (VI_SUCCESS > errStatus) {
      printf("ERROR: viClose() returned 0x%x\n", errStatus);
      return 0;}

    /* Close the resource manager session */
   errStatus = viClose (viRM);
   if (VI_SUCCESS > errStatus) {
      printf("ERROR: viClose() returned 0x%x\n", errStatus);
      return 0;}

   return VI_SUCCESS;
}
```

Scanning Channels

For the E8481A Matrix Switch module, scanning channels consists of closing a set of channels, one at a time. You can scan any combination of channels for a single-module or a multiple-module switchbox. Single, multiple, or continuous scanning modes are available.

Use TRIGger:SOURce command to specify the source to advance the scan. Use OUTPut subsystem commands to select the E1406A command module Trig Out port, or ECL Trigger bus lines (0-1), or TTL Trigger bus lines (0-7). Use ARM:COUNt <*number*> to set multiple/continuous scans (from 1 to 32,767 scans). Use INITiate:CONTinuous ON to set continuous scanning. See Chapter 4 of this manual for information about these SCPI commands.

Example: Scanning Channels Using Trig In/Out Ports

This example uses E1406A command module's "Trig In" and "Trig Out" ports to synchronize the matrix module channel closures with an external measurement multimeter (Agilent 34401A). See Figure 3-1 for typical user connections. For measurement synchronization:

- -- E1406A's **Trig Out** port (connected to the 34401A multimeter's **External Trigger** port) is used by the matrix module to trigger the multimeter to perform a measurement.
- -- E1406A's **Trig In** port (connected to the 34401A multimeter's **Voltmeter Complete** port) is used by the multimeter to advance the matrix scan.

For this example, Row 00 (High and Low) of the E8481A matrix module is connected to the multimeter's High and Low. The columns 00 through 15 are then scanned and different Device Under Test (DUTs) are switched in for a measurement.

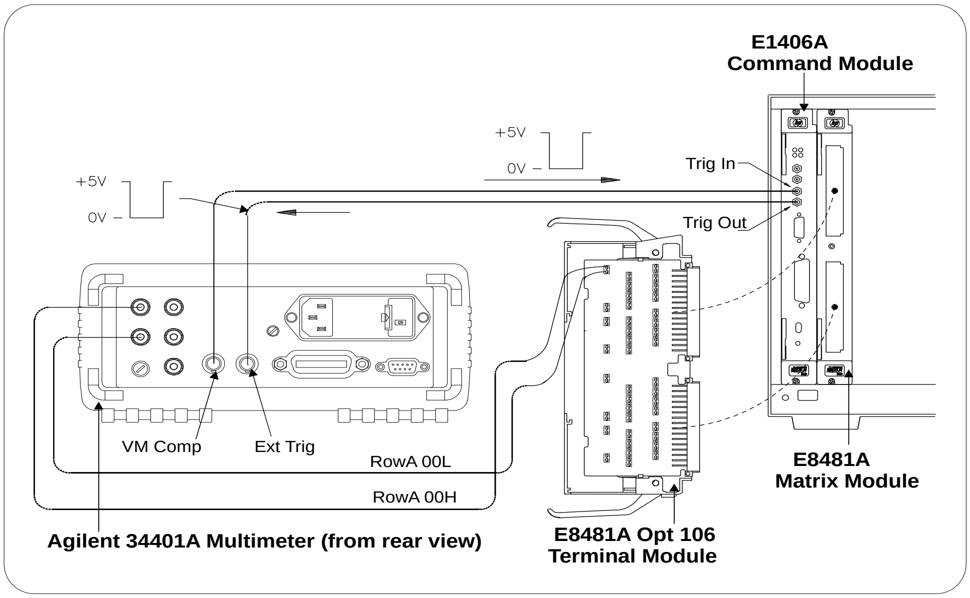


Figure 3-1. Scanning Channels using Trig In/out Ports

Programming with HTBasic

The following HTBasic program sets up the external multimeter (Agilent 34401A) to scan making DC voltage measurements. The Matrix module has a logical address 112 (secondary address 14), and the external multimeter has an address of 722.

```
10  DIM Rdgs(1:16)                  ! Dimension a variable to store
                                      readings.
20  OUTPUT 722; "*RST;*CLS"         ! Reset the dmm and clear its
                                      status registers.
30  OUTPUT 70914; "*RST;*CLS"       ! Reset the matrix module and
                                      clear its status registers.
40  OUTPUT 722; "CONF:VOLT:DC 12"   ! Set the dmm for DCV
                                      measurement, 12 V  maximum.
50  OUTPUT 722; "TRIG:SOUR EXT"     ! Set the dmm trigger source to
                                      EXTernal triggering.
60  OUTPUT 722; "TRIG:COUN 16"      ! Set the dmm trigger count to16.
70  OUTPUT 722; "INIT"              ! Set the dmm to the
                                      wait-for-trigger state.
80  WAIT 1                          ! Wait for 1 second.

90  OUTPUT 70914; "OUTP ON"         ! Set the matrix output pulses on
                                      E1406A "Trig Out" port when
                                      channel closed.
100 OUTPUT 70914; "TRIG:SOUR EXT"   ! Set the matrix trigger source to
                                      external triggering.
```

```
110 OUTPUT 70914; "SCAN (@10000:10015)"
                                          ! Define channel list (row 00,
                                            columns 00-15) for scanning.
120 OUTPUT 70914; "INIT"                  ! Start scan and close channel
                                            10000.
130 OUTPUT 722; "FETCH?"                  ! Read measurement results
                                            from the dmm.
140 ENTER 722; Rdgs(*)                    ! Enter measurement results.
150 PRINT Rdgs(*)                         ! Display measurement results.
160 END
```

Programming with C/C++

The following program was written and tested in Microsoft® Visual C++ using the VISA extensions but should compile under any standard ANSI C compiler. This example configures the external multimeter (Agilent 34401A) to scan making DC voltage measurements.

```
#include <visa.h>
#include <stdio.h>
#include <stdlib.h>

    /* Interface logical address is 112, Matrix secondary address is 14 */
#define INSTR_ADDR "GPIB0::9::14::INSTR"
    /* interface address for 34401A Multimeter */
#define MULTI_ADDR "GPIB0::22::INSTR"

int main()
{
   ViStatus errStatus;                    /* Status from each VISA call */
   ViSession viRM;                        /* Resource manager session */
   ViSession E8481A;                      /* Module session  */
   ViSession dmm;                         /* Multimeter session */
   int loop;                              /* loop counter */
   int opc_int;                           /* OPC? variable */
   double readings [16];                  /* Reading storage */

    /* Open the default resource manager */
   errStatus = viOpenDefaultRM (&viRM);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpenDefaultRM() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Open the matrix module instrument session */
   errStatus = viOpen(viRM,INSTR_ADDR, VI_NULL,VI_NULL,&E8481A);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpen() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Open the multimeter instrument session */
   errStatus = viOpen(viRM,MULTI_ADDR, VI_NULL,VI_NULL,&dmm);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpen() returned 0x%x\n", errStatus);
      return errStatus;}
```

```
/* Set timeout value for multimeter and matrix module */
viSetAttribute (dmm,VI_ATTR_TMO_VALUE,1000000);
viSetAttribute (E8481A,VI_ATTR_TMO_VALUE,1000000);

/* Reset the multimeter and clear its status registers */
errStatus = viPrintf(dmm, "*RST;*CLS\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

/* Configure dmm for DCV measurements, 12V maximum */
errStatus = viPrintf(dmm, "CONF:VOLT:DC 12\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

/* Set multimeter trigger source to EXTernal */
errStatus = viPrintf(dmm, "TRIG:SOUR EXT\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

/* Set multimeter trigger count to 16 */
errStatus = viPrintf(dmm, "TRIG:COUN 16\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

/* Initialize multimeter, wait for triggering */
errStatus = viPrintf(dmm, "INIT\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

/* Wait for 1 second */
_sleep(1000);

/* Reset matrix module and clear its status registers */
errStatus = viPrintf(E8481A, "*RST;*CLS\n");
if (VI_SUCCESS > errStatus) {
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

/* Enable matrix module output pulses on E1406A "Trig Out" port */
/* when a channel is closed */
errStatus = viPrintf(E8481A, "OUTP ON\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}
```

```
  /* Set matrix trigger source to EXTernal */
errStatus = viPrintf(E8481A, "TRIG:SOUR EXT\n");
if(VI_SUCCESS > errStatus){
   printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
   return errStatus;}

  /* Set up a scan list */
errStatus = viPrintf(E8481A, "SCAN (@10000:10015)\n");
if(VI_SUCCESS > errStatus){
   printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
   return errStatus;}

  /* Pause until ready */
errStatus = viQueryf(E8481A, "*OPC?\n", "%t", opc_int);
if(VI_SUCCESS > errStatus){
   printf("ERROR: viQueryf() returned 0x%x\n", errStatus);
   return errStatus;}

  /* Start scan and close channel 10000 */
errStatus = viPrintf(E8481A, "INIT\n");
if(VI_SUCCESS > errStatus){
   printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
   return errStatus;}

  /* Wait for scan to complete */
errStatus = viPrintf(E8481A, "STAT:OPER:ENAB 256\n");
if(VI_SUCCESS > errStatus){
   printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
   return errStatus;}

for (; ;){
   errStatus = viQueryf(E8481A, "*STB?\n", "%d", &opc_int);
   if (opc_int&0x80)
     break;}
printf("Scan has completed!");

  /* Get readings from the multimeter */
errStatus = viQueryf(dmm, "FETC?\n", "%,16lf", readings);
if(VI_SUCCESS > errStatus){
   printf("ERROR: viQueryf() returned 0x%x\n", errStatus);
   return errStatus;}

  /* Display the measurement results */
for (loop=0;loop<16;loop++) {
   printf ("Reading %d is: %lf\n", loop, readings[loop]);  }

  /* Close the E8481A instrument session */
errStatus = viClose (E8481A);
if (VI_SUCCESS > errStatus) {
   printf("ERROR: viClose() returned 0x%x\n", errStatus);
   return 0;}
```

```
    /* Close the multimeter instrument session */
    errStatus = viClose (dmm);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viClose() returned 0x%x\n", errStatus);
        return 0;}

    /* Close the resource manager session */
    errStatus = viClose (viRM);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viClose() returned 0x%x\n", errStatus);
        return 0;}

    return VI_SUCCESS;
}
```

Example: Scanning Channels Using TTL Trigger

This example uses E1406A command module's TTL Trigger Bus Lines to synchronize matrix channel closures with a system multimeter (Agilent E1412A). See Figure 3-2 for typical user connections. For measurement synchronization:

-- E1406A's TTL Trigger Bus Line 0 is used by the matrix module to trigger the multimeter to perform a measurement.

-- E1406A's TTL trigger bus line 1 is used by the multimeter to advance the matrix scan.

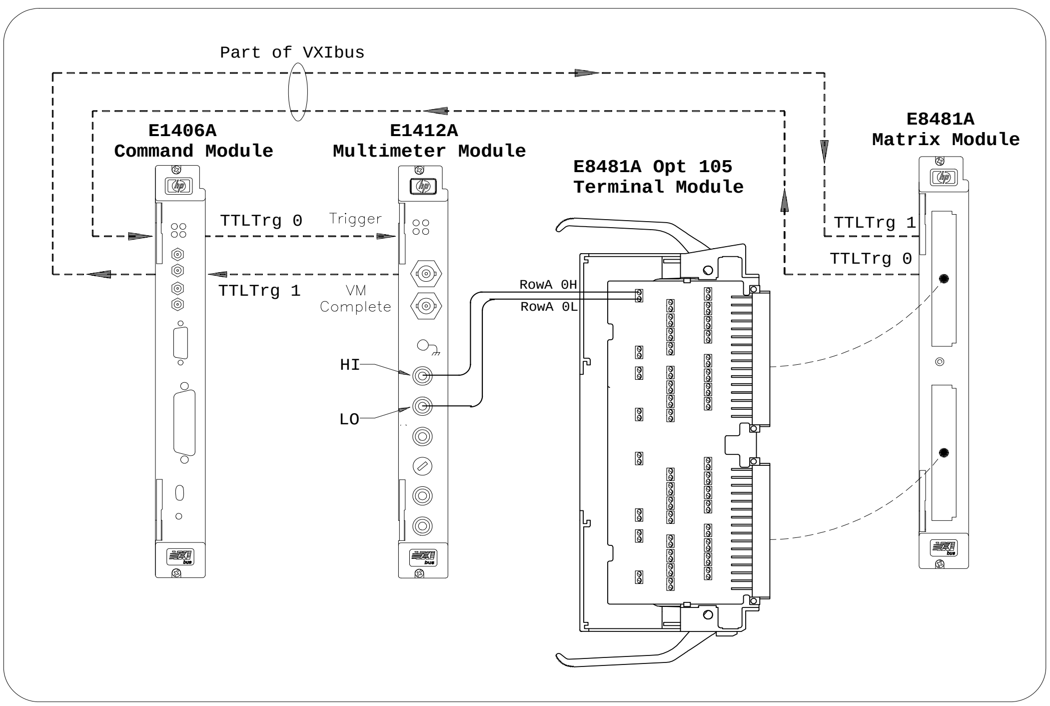


Figure 3-2. Scanning Using TTL Trigger Bus Lines

Figure 3-2 shows how to connect the matrix module to the E1412A multimeter module. The connections shown with dotted lines are not actual hardware connections. These connections indicate how the E1406A firmware operates to accomplish the triggering. For this example, Row 00 (High and Low) of the E8481A matrix module is connected to the multimeter's High and Low. The columns are then scanned and different DUTS are switched in for a measurement.

Programming with HTBasic

This example program was written in HTBasic programming language. It configures the multimeter (E1412A) for DC voltage measurements, sets the matrix module to scan channels on row 00, columns 00 through 15. The E1412A multimeter has a GPIB address of 70903 and the matrix module has a logical address of 112 (GPIB address of 70914).

```
10  DIM Rdgs(1:16)                      ! Dimension a variable to
                                          store readings.
20  OUTPUT 70903; "*RST;*CLS"           ! Reset the dmm and clear its
                                          status registers.
30  OUTPUT 70914; "*RST;*CLS"           ! Reset the matrix module and
                                          clear its status registers.
40  OUTPUT 70903; "CONF:VOLT 12,MIN"    ! Set the dmm for DCV
                                          measurement, 12 V max, min
                                          resolution.
50  OUTPUT 70903; "OUTP:TTLT1:STAT ON"
                                        ! Set the dmm pulses TTL trigger
                                          line 1 on measurement
                                          complete.
60  OUTPUT 70903; "TRIG:SOUR TTLT0"     ! Set the dmm to be triggered by
                                          TTL trigger line 0.
70  OUTPUT 70903; "TRIG:DEL 0.01"       ! Set the dmm trigger delay time
                                          to 10 ms
80  OUTPUT 70903; "TRIG:COUN 16"        ! Set the dmm trigger count to16.

90  OUTPUT 70903; "*OPC?"               ! Check to see if dmm ready
100 ENTER 70903; Check
110 OUTPUT 70903; "INIT"                ! Set the dmm to the
                                          wait-for-trigger state.

120 OUTPUT 70914; "OUTP:TTLT0:STAT ON"
                                        ! Set the matrix pulses TTL
                                          trigger line 0 on channel
                                          closed.
130 OUTPUT 70914; "TRIG:SOUR TTLT1"     ! Set the matrix to be triggered
                                          by TTL Trigger line 1.
140 OUTPUT 70914; "SCAN (@10000:10015)"
                                        ! Define channel list (row 00,
                                          columns 00-15) to be scanned.
150 OUTPUT 70914; "INIT"                ! Initialize scan and close
                                          channel 10000.

160 OUTPUT 70903; "FETCH?"              ! Read measurement results
                                          from the dmm.
170 ENTER 70903; Rdgs(*)                ! Enter measurement results.
180 PRINT Rdgs(*)                       ! Display measurement results.
190 END
```

Programming with C/C++

The following program was written and tested in Microsoft® Visual C++ using the VISA extensions but should compile under any standard ANSI C compiler. This example configures the multimeter for DC voltage measurements, sets the matrix module to scan channels on row 00, columns 00 through 15.

```
#include <visa.h>
#include <stdio.h>
#include <stdlib.h>

    /* Interface logical address is 112, module secondary address is 14 */
#define INSTR_ADDR "GPIB0::9::14::INSTR"
    /* Interface address for E1412 Multimeter */
#define MULTI_ADDR "GPIB0::9::3::INSTR"

int main()
{
   ViStatus errStatus;                    /* Status from each VISA call */
   ViSession viRM;                        /* Resource manager session */
   ViSession E8481A;                      /* Module session */
   ViSession E1412A;                      /* Multimeter session */

   int loop;                              /* loop counter */
   char opc_int[21];                      /* OPC? variable */
   double readings [16];                  /* Reading storage */

    /* Open the default resource manager  */
   errStatus = viOpenDefaultRM (&viRM);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpenDefaultRM() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Open the matrix module instrument session */
   errStatus = viOpen(viRM,INSTR_ADDR, VI_NULL,VI_NULL,&E8481A);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpen() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Open the multimeter instrument session */
   errStatus = viOpen(viRM,MULTI_ADDR, VI_NULL,VI_NULL,&E1412A);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpen() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Set timeout value for multimeter and matrix module */
   viSetAttribute (E1412A,VI_ATTR_TMO_VALUE,1000000);
   viSetAttribute (E8481A,VI_ATTR_TMO_VALUE,1000000);

    /* Reset the multimeter, clear status system */
   errStatus = viPrintf(E1412A, "*RST;*CLS\n");
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
      return errStatus;}
```

```
  /* Configure multimeter for DCV measurements, 12 V max, min resolution */
errStatus = viPrintf(E1412A, "CONF:VOLT 12,MIN\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

  /* Set multimeter to be triggered by TTL Trigger Line 0 */
errStatus = viPrintf(E1412A, "TRIG:SOUR TTLT0\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

  /* Enable the dmm pulses TTL trigger line 1 on measurement complete */
errStatus = viPrintf(E1412A, "OUTP:TTLT1 ON\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

  /* Set trigger delay time to 1 ms, trigger count to 16 */
errStatus = viPrintf(E1412A, "TRIG:DEL 0.001;COUN 16\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

  /* Pause until multimeter is ready */
errStatus = viQueryf(E1412A, "*OPC?\n", "%t", opc_int);
if(VI_SUCCESS > errStatus){
    printf("ERROR: viQueryf() returned 0x%x\n", errStatus);
    return errStatus;}

  /* Initialize multimeter, wait for trigger */
errStatus = viPrintf(E1412A, "INIT\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

  /* Reset the matrix module, clear the status registers */
errStatus = viPrintf(E8481A, "*RST;*CLS\n");
if (VI_SUCCESS > errStatus) {
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

  /* Set the matrix pulses TTL Trigger line 0 on channel closed */
errStatus = viPrintf(E8481A, "OUTP:TTLT0 ON\n");
if(VI_SUCCESS > errStatus){
    printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
    return errStatus;}

  /* Set the matrix to be triggered by TTL Trigger line 1 */
errStatus = viPrintf(E8481A, "TRIG:SOUR TTLT1\n");
if(VI_SUCCESS > errStatus){
```

```
        printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
        return errStatus;}

    /* Set up a scan list */
    errStatus = viPrintf(E8481A, "SCAN (@10000:10015)\n");
    if(VI_SUCCESS > errStatus){
        printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
        return errStatus;}

    /* Pause until ready */
    errStatus = viQueryf(E8481A, "*OPC?\n", "%t", opc_int);
    if(VI_SUCCESS > errStatus){
        printf("ERROR: viQueryf() returned 0x%x\n", errStatus);
        return errStatus;}

    /* Start scan and close channel 10000 */
    errStatus = viPrintf(E8481A, "INIT\n");
    if(VI_SUCCESS > errStatus){
        printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
        return errStatus;}

    /* Get readings from multimeter */
    errStatus = viQueryf(E1412A, "FETC?\n", "%,16lf", readings);
    if(VI_SUCCESS > errStatus){
        printf("ERROR: viQueryf() returned 0x%x\n", errStatus);
        return errStatus;}

    /* Display measurement results */
    for (loop=0;loop<16;loop++) {
        printf ("Reading %d is: %lf\n", loop, readings[loop]);  }

    /* Close the E8481A instrument session */
    errStatus = viClose (E8481A);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viClose() returned 0x%x\n", errStatus);
        return 0;}

    /* Close the multimeter instrument session */
    errStatus = viClose (E1412A);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viClose() returned 0x%x\n", errStatus);
        return 0;}

    /* Close the resource manager session */
    errStatus = viClose (viRM);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viClose() returned 0x%x\n", errStatus);
        return 0;}

    return VI_SUCCESS;
}
```

Using the Scan Complete Bit

You can use the Scan Complete bit (bit 8) in the Operation Status Register (in the command module) of a switchbox to determine when a scanning cycle completes (no other bits in the register apply to the switchbox). Bit 8 has a decimal value of 256 and you can read it directly with the STATus:OPERation[:EVENt]? command. See Page 84 in Chapter 4 for more information.

When enabled by the STAT:OPER:ENAB 256 command, the Scan Complete bit will be reported as bit 7 of the Status Byte Register. Use the GPIB Serial Poll or the IEEE 488.2 Common Command *STB? to read the Status Byte Register.

When bit 7 of the Status Register is enabled by the *SRE 128 Common Command to assert a GPIB Service Request (SRQ), you can interrupt the computer when the Scan Complete bit is set, after a scanning cycle completes. This allows the computer to do other operations while the scanning cycle is in progress.

The following example programs were written in HTBasic and Visual C/C++ programming language respectively. It monitors bit 7 of the Status Byte Register to determine when the scanning cycle is complete. The computer interfaces with the E1406A command module over GPIB. The GPIB select code is 7, the GPIB primary address is 09, and the GPIB secondary address is 14.

Example: Using the Scan Complete Bit (HTBasic)

```
10   OUTPUT 70914; "*RST;*CLS"              ! Reset and clear the matrix.
20   OUTPUT 70914; "STATUS:OPER:ENABLE 256"
                                            ! Enable Scan Complete Bit.
30   OUTPUT 70914; "TRIG:SOUR IMM"          ! Set the matrix for internal
                                              triggering.
40   OUTPUT 70914; "SCAN (@10000:10015)"
                                            ! Set up channel list to scan.
50   OUTPUT 70914; "*OPC?"                  ! Wait for operation complete.
60   ENTER 70914; A$
70   PRINT 70914; "*OPC? =";A$
80   OUTPUT 70914; "*STB?"                  ! Query status byte register.
90   ENTER 70914; A$
100  PRINT "Switch Status = "; A$
110  OUTPUT 70914; "INIT"                   ! Start scan cycle and close the
                                              channel 10000.
120  I =0
130  WHILE(I =0)                            ! Stay in loop until value
                                              returned from the command
                                              SPOLL (70914).
140     I = SPOLL (70914)
150     PRINT "Waiting for scan to complete..."
160  END WHILE

170  I = SPOLL (70914)                      ! "128" returned indicates scan
                                              has completed.
180  PRINT "Scan complete: spoll = ";I
190  END
```

Example: Using the Scan Complete Bit (C/C++)

```
#include <visa.h>
#include <stdio.h>
#include <stdlib.h>

    /* Interface logical address is 112, module secondary address is 14 */
#define INSTR_ADDR "GPIB0::9::14::INSTR"

int main()
{
   ViStatus errStatus;                          /* Status from each VISA call */
   ViSession viRM;                              /* Resource manager session */
   ViSession E8481A;                            /* Module session */
   int scan;                                    /* Scan Complete Bit* / 

    /* Open the default resource manager */
   errStatus = viOpenDefaultRM (&viRM);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpenDefaultRM() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Open the module instrument session */
   errStatus = viOpen(viRM,INSTR_ADDR, VI_NULL,VI_NULL,&E8481A);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpen() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Set timeout value for the module */
   viSetAttribute (E8481A,VI_ATTR_TMO_VALUE,1000000);

    /* Reset the module and clear its status registers */
   errStatus = viPrintf(E8481A, "*RST;*CLS\n");
   if (VI_SUCCESS > errStatus) {
      printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Enable the Scan Complete Bit */
   errStatus = viPrintf(E8481A, "STAT:OPER:ENAB 256\n");
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Set trigger source to IMMediate for internal triggering */
   errStatus = viPrintf(E8481A, "TRIG:SOUR IMM\n");
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
      return errStatus;}

    /* Specify a channel list for scanning */
   errStatus = viPrintf(E8481A, "SCAN (@10000:10005)\n");
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
      return errStatus;}
```

```
  /* Start scan and close channel 10000 */
  errStatus = viPrintf(E8481A, "INIT\n");
  if(VI_SUCCESS > errStatus){
     printf("ERROR: viPrintf() returned 0x%x\n", errStatus);
     return errStatus;}

  /* Stay in loop until scan complete */
  for (; ;){
     errStatus = viQueryf(E8481A, "*STB?\n", "%d", &scan);
     printf("Waiting for scan to complete...");
     if (scan&0x80)
       break;}
  printf("Scan has completed!");

  /* Close the module instrument session */
  errStatus = viClose (E8481A);
  if (VI_SUCCESS > errStatus) {
     printf("ERROR: viClose() returned 0x%x\n", errStatus);
     return 0;}

  /* Close the resource manager session */
  errStatus = viClose (viRM);
  if (VI_SUCCESS > errStatus) {
     printf("ERROR: viClose() returned 0x%x\n", errStatus);
     return 0;}

  return VI_SUCCESS;
}
```

Querying the Matrix Module

All query commands end with a "?". The data is sent to the output buffer where you can retrieve it into your computer to obtain the specific information of the module. The following lists some of the query commands often used. See Chapter 4 for more details of the related commands.

Channel closed:	CLOS?
Channel open:	OPEN?
Function Mode:	FUNC?
Channel closed in Pattern:	PATT:CLOS?
Channel open in Pattern:	PATT:OPEN?
Pattern number:	PATT:NUMB?
Pattern activated:	PATT:ACT?
Module Description:	SYST:CDES?
Module Type:	SYST:CTYP?
System error:	SYST:ERR?

Recalling and Saving States

The *SAV <*numeric_state*> command saves the current instrument state. Up to 10 states can be stored by specifying the *numeric_state* parameter as an integer 0 through 9. The settings saved by this command are as follows:

- Channel relays states (open or closed)
- ARM:COUNt
- TRIGger:SOURce
- OUTPut:STATe
- INITiate:CONTinuous

The *RCL <*numeric_state*> command recalls a previously saved state specified by the *numeric_state* parameter. If no *SAV was previously executed for the *numeric_state*, the matrix module will configure to its power-on/reset state (refer to Table 3-1).

Example: Saving and Recalling Instrument State (HTBasic)

The following HTBasic program shows how to save and recall the matrix switch states. It first closes channels 10000 through 10015, then saves current channel states to the state 5. After reset the module to open all channels of the module, then recall the stored state 5 and verify whether the channels are set to the saved state (channels 10000 through 10015 are closed).

```
10   DIM A$[100]                        ! Dimension a string variables to
                                          30 characters.
20   OUTPUT 70914; "*RST; *CLS"         ! Reset the module and clear
                                          status registers.
30   OUTPUT 70914; "CLOS (@10000:10015)"
                                        ! Close channel relays on
                                          row 0, column 00 -15 of the
                                          matrix module.
40   OUTPUT 70914; "*SAV 5"             ! Save all channel states as
                                          numeric state 5.
50   OUTPUT 70914; "*RST; *CLS"         ! Reset the module and clear
                                          status register.
60   OUTPUT 70914; "CLOS? (@10000:10031)"
                                        ! Query to see what channel
                                          relays are closed on Row 0.
70   ENTER 70914; A$
80   PRINT "Channels Closed: "; A$      ! Display the closed channels.
90   OUTPUT 70914; "*RCL 5"             ! Recall the state 5.
100  OUTPUT 70914; "CLOS? (@10000:10031)"
                                        ! Query to see what channel
                                          relays are closed on Row 0.
110  ENTER 70914; A$
120  PRINT "Channels Closed: "; A$      ! Print 1s for the first 16
                                          channels that are closed  and
                                          0s for the remaining 16
                                          channels.
130  END
```

Detecting Error Conditions

The SYSTem:ERRor? command queries the instrument's error queue for error conditions. If no error occurs, the matrix module responds with 0,"No error". If errors do occur, the module will respond with the first one in its error queue. Subsequent queries continue to read the error queue until it is empty. The response takes the following form:

<err_number>, <err_message>

where *<err_number>* is an integer ranging from -32768 to 32767, and the *<err_message>* is a short description of the error and the maximum string length is 255 characters.

Example: Querying Errors (HTBasic)

The following example program was written in HTBasic programming language. It attempts an illegal channel closure for the E8481A matrix module, then polls for the error message.

```
10 DIM Err_num$[256]                  ! Dimension a string variable.
20 OUTPUT 70914; "CLOS (@10500)"      ! Try to close an illegal channel.
30 OUTPUT 70914; ":SYST:ERR?"         ! Check for a system error.
40 ENTER 70914;Err_num$               ! Enter the error into Err_num$.
50 PRINT "Error: ";Err_num$           ! Print error +2001, "Invalid
                                        channel number".
60 END
```

Synchronizing the Instruments

This section shows how to synchronize a matrix module with other instruments when making measurements. In the following example, the matrix module switches a signal to a multimeter, then verifies that the switching is complete before the multimeter begins a measurement.

Example: Synchronizing the Instruments (HTBasic)

This example program was written in HTBasic language. Assuming the multimeter (E1412A) has the GPIB address of 70903 and the matrix module has a logical address of 112 (GPIB address of 70914).

```
10   OUTPUT 70914; "*RST"                  ! Reset the module.
20   OUTPUT 70914; "CLOS (@10001)"         ! Close a channel.
30   OUTPUT 70914; "*OPC?"                 ! Wait for operation complete.
40   ENTER 70914; OPC_value
50   OUTPUT 70914; "CLOS? (@10001)"        ! Verify that the channel is
                                             closed.
60   ENTER 70914;A
70   IF A=1 THEN
80      OUTPUT 70903; "MEAS:VOLT:DC?"      ! When channel is closed, make
                                             the measurement.
90      ENTER 70903; Meas_value
100     PRINT Meas_value                   ! Print the measured value.
110  ELSE
120     PRINT "CHANNEL DID NOT CLOSE"
130  END IF
140  END
```

Notes:

Chapter 4
Command Reference

Using This Chapter

This chapter describes Standard Commands for Programmable Instruments (SCPI) and summarizes IEEE 488.2 Common (*) commands applicable to the module. See the *Agilent E1406A Command Module User's Manual* for additional information on SCPI and common commands. This chapter contains the following sections:

Command Types

Commands are separated into two types: IEEE 488.2 Common Commands and SCPI Commands.

Common Command Format

The IEEE 488.2 standard defines the common commands that perform functions such as reset, self-test, status byte query, and so on. Common commands are four or five characters in length, always begin with an asterisk (*), and may include one or more parameters. The command keyword is separated from the first parameter by a space character. Some examples of common commands are shown below:

*RST   *ESR <*unmask*>   *STB?

SCPI Command Format

The SCPI commands perform functions like closing/opening switches, making measurements, querying instrument states or retrieving data. A subsystem command structure is a hierarchical structure that usually consists of a top level (or root) command, one or more lower level commands, and their parameters. The following example shows part of a typical subsystem:

```
[ROUTe:]
    CLOSe <channel_list>
    SCAN <channel_list>
```

[ROUTe:] is the root command, CLOSe and SCAN are the second level commands with <*channel_list*> as a parameter.

Command Separator

A colon (:) always separates one command from the next lower level command as shown below:

ROUTe:SCAN <*channel_list*>

Colons separate the root command from the second level command (ROUTe:SCAN). If a third level existed, the second level is also separated from the third level by a colon.

Abbreviated Commands

The command syntax shows most commands as a mixture of upper and lower case letters. The upper case letters indicate the abbreviated spelling for the command. For shorter program lines, send the abbreviated form. For better program readability, you may send the entire command. The instrument will accept either the abbreviated form or the entire command.

For example, if the command syntax shows TRIGger, then TRIG and TRIGGER are both acceptable forms. Other forms of TRIGger, such as TRIGG or TRIGGE will generate an error. You may use upper or lower case letters. Therefore, TRIGGER, trigger, and TrIgGeR are all acceptable.

Implied Commands

Implied commands are those which appear in square brackets ([ ]) in the command syntax. (Note that the brackets are not part of the command and are not sent to the instrument.) Suppose you send a second level command but do not send the preceding implied command. In this case, the instrument assumes you intend to use the implied command and it responds as if you had sent it. Examine the partial [ROUTe:] subsystem shown below:

```
[ROUTe:]
    CLOSe?  <channel_list>
```

The root command [ROUTe:] is an implied command. To make a query about a channel's present status, you can send either of the following command statements:

ROUT:CLOS? <*channel_list*> ***or*** CLOS? <*channel_list*>

Variable Commands

Some commands have what appears to be a variable syntax. For example:

OUTPut:TTLTrg*n*

In this command, the "*n*" is replaced by a number (range from 0 to 7). No space is left between the command and the number because the number is part of the command syntax instead of a parameter.

Parameters

Parameter Types. The following table contains explanations and examples of parameter types you might see later in this chapter.

Parameter Type	Explanations and Examples
Numeric	Accepts all commonly used decimal representations of number including optional signs, decimal points, and scientific notation. 123, 123E2, -123, -1.23E2, .123, 1.23E-2, 1.23000E-01. Special cases include MINimum, MAXimum, and DEFault.
Boolean	Represents a single binary condition that is either true or false ON, OFF, 1, 0
Discrete	Selects from a finite number of values. These parameters use mnemonics to represent each valid setting. An example is the TRIGger:SOURce <*source*> command where source can be BUS, EXT, HOLD, or IMM.

Optional Parameters. Parameters shown within square brackets ([ ]) are optional parameters. (Note that the brackets are not part of the command and are not sent to the instrument.) If you do not specify a value for an optional parameter, the instrument uses the default value. For example, consider the ARM:COUNt?[<MIN | MAX>] command. If you send the command without specifying a parameter, the present ARM:COUNt setting is returned. If you send the MIN parameter, the command returns the minimum count available. If you send the MAX parameter, the command returns the maximum count available. Be sure to place a space between the command and the parameter.

Linking Commands

Linking IEEE 488.2 Common Commands with SCPI Commands. Use a semicolon (**;**) between the commands. For example:

*RST;CLOS (@100)   ***or***   TRIG:SOUR BUS;*TRG

Linking Multiple SCPI Commands. Use both a semicolon (**;**) and a colon (**:**) between the commands. For example:

ARM:COUN1;:TRIG:SOUR EXT

SCPI also allows several commands within the same subsystem to be linked with a semicolon. For example:

ROUT:CLOS (@100);:ROUT:CLOS? (@100)

- *or* -

ROUT:CLOS (@100);CLOS? (@100)

SCPI Command Reference

This section describes the Standard Commands for Programmable Instruments (SCPI) reference commands for the Matrix Switch module. Commands are listed alphabetically by subsystem and also within each subsystem.

The **ABORt** command stops a scan in progress when the scan is enabled via the interface, and the trigger source is either TRIGger:SOURce BUS or TRIGger:SOURce HOLD.

Subsystem Syntax

ABORt

Comments

ABORt Actions: The ABORt command terminates the scan and invalidates the current channel list. When the ABORt command is executed, the last channel closed during scanning remains in the closed position.

Affect on Scan Complete Status Bit: Aborting a scan will not set the "scan complete" status bit.

Stopping Scan Enabled Via Interface: When a scan is enabled via an interface, and the trigger source is neither HOLD nor BUS, an interface clear command (CLEAR 7 or viClear () function in VISA) can be used to stop the scan. When the scan is enabled via the interface and TRIGger:SOURce BUS or HOLD is set, you can use ABORt command to stop the scan.

Restarting a Scan: Use the INIT command to restart the scan.

Related Commands: ARM, INITiate:CONTinuous, [ROUTe:]SCAN, TRIGger

Example

Stopping a Scan with ABORt

This example stops a continuous scan in progress.

```
TRIG:SOUR  BUS                 ! BUS is trigger source.
INIT:CONT  ON                  ! Set continuous scanning.
SCAN  (@10000:10003)           ! Set channel list to be scanned.
INIT                           ! Start scan, close channel 10000.
 .
 .
 .
ABOR                           ! Abort scan in progress.
```

The **ARM** subsystem selects the number of scanning cycles (1 to 32,767) for each INITiate command.

Subsystem Syntax

```
ARM
    :COUNt  <number>  MIN | MAX
    :COUNt?  [<MIN | MAX>]
```

ARM:COUNt

ARM:COUNt *<number>* MIN | MAX allows scanning cycles to occur a multiple of times (1 to 32,767) with one INITiate command when INITiate:CONTinuous OFF | 0 is set. MIN sets 1 cycle and MAX sets 32,767 cycles.

Parameters

Name	Type	Range of Values	Default Value
<number>	numeric	1 - 32,767 | MIN | MAX	1

Comments

Number of Scans: Use only values between 1 to 32767, MIN, or MAX for the number of scanning cycles.

Related Commands: ABORt, INITiate[:IMMediate], INITiate:CONTinuous

***RST Condition:** ARM:COUNt 1

Example

Setting Ten Scanning Cycles

This example sets the relay matrix to scan channels 10000 through 10003 for ten times.

```
ARM:COUN  10                    ! Set 10 scanning cycles.
SCAN (@10000:10003)             ! Scan channels 10000 to 10003.
INIT                            ! Start scan, close channel 10000.
```

ARM:COUNt?

ARM:COUNt? [<MIN | MAX>] returns the current number of scanning cycles set by ARM:COUNt. The current number of scan cycles is returned when MIN or MAX parameter is not specified. With MIN or MAX as a parameter, "1" is returned for the MIN parameter; or "32767" is returned for the MAX parameter regardless of the ARM:COUNt value set.

Parameters

Name	Type	Range of Values	Default Value
<MIN | MAX>	numeric	MIN = 1, MAX = 32,767	current cycles

Comments

Related Commands: INITiate[:IMMediate]

Example

Querying Number of Scanning Cycles

This example sets 10 scanning cycles, then queries the setting.

ARM:COUN 10	*! Set 10 scanning cycles per INIT command.*
ARM:COUN?	*! Query number of scanning cycles.*

The **DIAGnostic** subsystem is used to control the module's interrupt capability, including disabling the interrupt, selecting an interrupt line. In addition, some potential failure may be identified with this subsystem.

Subsystem Syntax

```
DIAGnostic
    :INTerrupt
        [:LINE]  <card_number>, <line_number>
        [:LINE]?  <card_number>
    :TEST
        [:RELays]?
        :SEEProm?  <card_number>
```

DIAGnostic:INTerrupt[:LINe]

DIAGnostic:INTerrupt[:LINe] *<card_number>, <line_number>* sets the interrupt line of the specified module. The *<card_number>* specifies which E8481A in a multiple-module switchbox, is being referred to. The *<line_number>* can be 1 through 7 corresponding to VXI backplane interrupt lines 1 through 7.

NOTE *Changing the interrupt priority level is not recommended. DO NOT change it unless specially instructed to do so. Refer to the E1406A Command Module User's Manual for more details.*

Parameters

Name	Type	Range of Values	Default Value
<card_number>	numeric	1 - 99	N/A
<line_number>	numeric	0 - 7	1

Comments

Disable Interrupt: Setting *<line_number>* = 0 will disable the module's interrupt capability.

Select an Interrupt Line: The *line_number* can be 1 through 7 corresponding to VXI backplane interrupt lines 1-7. Only one value can be set at one time. The default value is 1 (lowest interrupt level).

Related Commands: DIAGnostic:INTerrupt:[LINe]?

Example

Setting Interrupt Line 1 for Module #1

DIAG:INT:LIN 1, 1 — *! Set the interrupt line of module #1 to line 1.*

DIAGnostic:INTerrupt[:LINe]?

DIAGnostic:INTerrupt[:LINe]? *<card_number>* queries the module's VXI backplane interrupt line and the returned value is one of 1, 2, 3, 4, 5, 6, 7 which corresponds to the module's interrupt lines 1-7. The returned value being 0 indicates that the module's interrupt is disabled. The *<card_number>* specifies which E8481A in a multiple-module switchbox is being referred to.

Parameters

Name	Type	Range of Values	Default Value
<card_number>	numeric	1 - 99	N/A

Comments

Return value of "0" indicates that the module's interrupt is disabled. Return values of 1-7 correspond to VXI backplane interrupt lines 1 through 7.

When power-on or reset the module, the default interrupt line is 1.

Example

Querying Module's Interrupt Line

DIAG:INT:LIN 1, 1	*! Set the interrupt line of module #1 to line 1.*
DIAG:INT:LIN? 1	*! Query the module's interrupt line.*

DIAGnostic:TEST[:RELays]?

DIAGnostic:TEST[:RELays]? causes the instrument to perform a self test which includes writing to and reading from all relay registers and verifying the correct values. A failure may indicate a potential hardware problem.

Comments

Returned Value: Returns 0 if all tests passed; otherwise the card fails.

Error Codes: If the card fails, the returned value is in the form ***100*card number + error code***. Error codes are:

1 = Internal driver error;
2 = VXI bus time out;
3 = Card ID register incorrect;
5 = Card data register incorrect;
10 = Card did not interrupt;
11 = Card busy time incorrect;
40 = Relay register read and written data don't match.

WARNING

Disconnect any connections to the module when performing this function.

Example

Perform Diagnostic Test to Check Error(s)

DIAG:TEST?	*! Returned "0" indicates that the system has passed the self test otherwise the system has an error.*

DIAGnostic:TEST:SEEProm?

DIAGnostic:TEST:SEEProm? *<card_number>* checks the integrity (checksum) of the serial EEPROM on the module. Return value of "0" if no error. Otherwise, return value of "-1".

Parameters

Name	Type	Range of Values	Default value
<card_number>	numeric	1 - 99	N/A

Comments

Related Commands: SYST:CTYPE? *<card_number>*

Example

Checking EEPROM Checksum on Module #1

DIAG:TEST:SEEProm? 1 *! Return "0" if no error.*

The **DISPlay** subsystem monitors the channel state of the selected module in a switchbox. This subsystem operates with an Agilent E1406A command module when a display terminal is connected. With an RS-232 terminal connected to the E1406A command module's RS-232 port, these commands control the display on the terminal, and would in most cases be typed directly from the terminal keyboard. It is possible however, to send these commands over the GPIB interface, and control the terminal's display. In this case, care must be taken that the instrument receiving the DISPlay command is the same one that is currently selected on the terminal; otherwise, the GPIB command will have no visible affect.

Subsystem Syntax

```
DISPlay
    :MONitor
        :CARD  <number>  | AUTO
        :CARD?
        [:STATe]  <mode>
        [:STATe]?
```

DISPlay:MONitor:CARD

DISPlay:MONitor:CARD <*number*> | AUTO selects the module in a switchbox to be monitored when the monitor mode is enabled. Use the DISPlay:MONitor:STATe command to enable or disable the monitor mode.

Parameters

Name	Type	Range of Values	Default Value
<*number*> | AUTO	numeric	1 - 99 | AUTO	AUTO

Comments

Selecting a specific module to be monitored: Use the DISPlay:MONitor:CARD command to send the card number for the switchbox to be monitored.

Selecting the present module to be monitored: Use the DISPlay:MONitor:CARD AUTO command to select the last module addressed by a switching command (for example, [ROUTe:]CLOSe).

***RST conditions:** DISPlay:MONitor:CARD AUTO

Example

Selecting Module #2 in a Switchbox for Monitoring

DISPlay:MONitor:CARD 2	*! Select module #2 in a switchbox to be monitored.*

DISPlay:MONitor:CARD?

DISPlay:MONitor:CARD? queries the setting of the DISPlay:MONitor:CARD command and returns the module in a switchbox being monitored.

DISPlay:MONitor[:STATe]

DISPlay:MONitor[:STATe] <*mode*> turns the monitor mode ON or OFF. When monitor mode is on, the RS-232 terminal display presents an array of values indicating the open/close state of channels on the module. The display is dynamically updated each time a channel is opened or closed.

Parameters

Name	Type	Range of Values	Default Value
<*mode*>	boolean	ON | OFF | 1 | 0	OFF | 0

Comments

Monitoring Switchbox Channels: DISPlay:MONitor[:STATe] ON or DISPlay:MONitor[:STATe] 1 turns the monitor mode on to show the channel state of the selected module. DISPlay:MONitor[:STATe] OFF or DISPlay:MONitor[:STATe] 0 turns the monitor mode off.

NOTE *Typing in another command on the RS-232 terminal will cause the* DISPlay:MONitor[:STATe] *to automatically be set to OFF (0). Use of the OFF parameter is useful only if the command is issued over the GPIB interface.*

Selecting the Module to be Monitored: Use the DISPlay:MONitor:CARD command to select the module.

Monitor Mode for the E8481A: When monitoring mode is turned on, the hexadecimal numbers (sixteen 16-bits) representing all channel states will be displayed at the bottom of the terminal. These numbers correspond to the contents of the sixteen Relay Control Registers (from base + 12_h to base + $2E_h$), see “Relay Control Registers” on page 104 for more information. Each channel uses two bits. The bits that are "11" represent the related channel is closed. The bits that are "00" indicate the related channel is open. For example, the display below shows that relays at row 0, columns 0-1, row 1, columns 6-7, and row 3, columns 16-31 are closed.

"00F0 0000 0000 F000 0000 0000 0000 0000 0000 0000 0000 0000
0000 0000 FFFF FFFF"

***RST Condition:** DISPlay:MONitor[:STATe] OFF | 0.

Example

Enabling the Monitor Mode for Module #2

```
DISP:MON:CARD 2        ! Select module #2 to be monitored.
DISP:MON ON            ! Turn on monitor mode.
```

DISPlay:MONitor[:STATe]?

DISPlay:MONitor[:STATe]? queries the monitor mode state whether it is set to ON or OFF.

The **INITiate** command subsystem selects continuous scanning cycles and starts the scanning cycle.

Subsystem Syntax

```
INITiate
    :CONTinuous <mode>
    :CONTinuous?
    [:IMMediate]
```

INITiate:CONTinuous

INITiate:CONTinuous *<mode>* enables or disables continuous scanning cycles for the matrix.

Parameters

Name	Type	Range of Values	Default Value
<mode>	boolean	ON | OFF | 1 | 0	OFF | 0

Comments

Continuous Scanning Operation: Continuous scanning is enabled with the INITiate:CONTinuous ON or INITiate:CONTinuous 1 command. Sending the INITiate:IMMediate command closes the first channel in the channel list. Each trigger from the trigger source specified by the TRIGger:SOURce command advances the scan through the channel list. A trigger at the end of the channel list closes the first channel in the channel list and the scan cycle repeats.

Noncontinuous Scanning Operation: Noncontinuous scanning is enabled with the INITiate:CONTinuous OFF or INITiate:CONTinuous 0 command. Sending the INITiate:IMMediate command closes the first channel in the channel list. Each trigger from the trigger source specified by the TRIGger:SOURce command advances the scan through the channel list. A trigger at the end of the channel list opens the last channel in the list and the scanning cycle stops.

Stopping Continuous Scan: Refer to the ABORt command on Page 56.

Related Commands: ABORt, ARM:COUNt, INITiate[:IMMediate], TRIGger:SOURce.

***RST Condition:** INITiate:CONTinuous OFF | 0

Example

Enabling Continuous Scanning

This example enables continuous scanning of channels 10000 through 10003 of a single-module switchbox. Since TRIGger:SOURce IMMediate (default) is set, use an interface clear command (such as CLEAR 7) to stop the scan.

```
INIT:CONT ON                ! Enable continuous scanning.
SCAN (@10000:10003)         ! Set channel list to be scanned.
INIT                        ! Start scan, close channel 10000.
```

INITiate:CONTinuous?

INITiate:CONTinuous? queries the scanning state. With continuous scanning enabled, the command returns "1" (ON). With continuous scanning disabled, the command returns "0" (OFF).

Example **Querying Continuous Scanning State**

```
INIT:CONT ON        ! Enable continuous scanning.
INIT:CONT?          ! Query continuous scanning state.
                      It returns "1" (ON).
```

INITiate[:IMMediate]

INITiate[:IMMediate] starts the scanning process and closes the first channel in the channel list. Successive triggers from the source specified by the TRIGger:SOURce command advances the scan through the channel list.

Comments **Starting the Scanning Cycle:** The INITiate:IMMediate command starts scanning by closing the first channel in the channel list. Each trigger received advances the scan to the next channel in the channel list. An invalid channel list generates an error (see [ROUTe:]SCAN on Page 80).

Stopping Scanning Cycles: Refer to the ABORt command.

Related Commands: ABORt, ARM:COUNt, INITiate:CONTinuous, TRIGger, TRIGger:SOURce

Example **Enabling a Single Scan**

This example enables a single scan of channels 1000 through 10003 of a single-module switchbox. The trigger source to advance the scan is immediate (internal) triggering set with TRIGger:SOURceIMMediate (default).

```
SCAN (@10000:10003)   ! Set channels to be scanned.
INIT                  ! Start scan, close channel 10000.
```

The **OUTPut** command subsystem selects the source of the output trigger generated when a channel is closed during a scan. The selected output can be enabled, disabled, or queried. The three available outputs are ECLTrg, TTLTrg trigger buses, and the "Trig Out" port on the command module's front panel (Agilent E1406A).

Subsystem Syntax

```
OUTPut
    :ECLTrgn       (:ECLTrg0 or :ECLTrg1)
        [:STATe]  <mode>
        [:STATe]?
    [:EXTernal]
        [:STATe]  <mode>
        [:STATe]?
    :TTLTrgn       (:TTLTrg0 through :TTLTrg7)
        [:STATe]  <mode>
        [:STATe]?
```

OUTPut:ECLTrg*n*[:STATe]

OUTPut:ECLTrg*n*[:STATe] *<mode>* selects and enables which ECL Trigger bus line (0 and 1) will output a trigger when a channel is closed during a scan. This is also used to disable a selected ECL Trigger bus line. "*n*" specifies the ECL Trigger bus line (0 or 1) and <*mode*> enables (ON or 1) or disables (OFF or 0) the specified ECL Trigger bus line.

Parameters

Name	Type	Range of Values	Default Value
n	numeric	0 or 1	N/A
<*mode*>	boolean	0 | 1 | OFF | ON	OFF | 0

Comments

Enabling ECL Trigger Bus: When enabled, a trigger pulse is output from the selected ECL Trigger bus line (0 or 1) each time a channel is closed during a scan. The output is a negative going pulse.

ECL Trigger Bus Line Shared by Switchboxes: Only one switchbox configuration can use the selected trigger at a time. When enabled, the selected ECL Trigger bus line (0 or 1) is pulsed by the switchbox each time a scanned channel is closed. To disable the output for a specific switchbox, send the OUTPut:ECLTrgn OFF or 0 command for that switchbox.

One Output Selected at a Time: Only one output (ECLTrg*n*, TTLTrg*n* or EXTernal) can be enabled at one time. Enabling a different output source will automatically disable the active output. For example, if ECLTrg0 is the active output and ECLTrg1 is enabled, ECLTrg0 will become disabled and ECLTrg1 will become the active output.

Related Commands: [ROUTe:]SCAN, TRIGger:SOURce, OUTPut:ECLTrg*n*[:STATe]?

***RST Condition:** OUTPut:ECLTrg*n*[:STATe] OFF (disabled)

Example **Enabling ECL Trigger Bus Line 0**

```
OUTP:ECLT0:STAT 1          ! Enable ECL Trigger bus line 0
                             to output pulse after each scanned
                             channel is closed.
```

OUTPut:ECLTrg*n*[:STATe]?

OUTPut:ECLTrg*n*[:STATe]? queries the state of the specified ECL Trigger bus line. The command returns "1" if the specified ECL Trg bus line is enabled or "0" if it is disabled.

Example **Querying ECL Trigger Bus Enable State**

This example enables ECL Trigger bus line 1 and queries the enable state. The OUTPut:ECLTrg*n*? command returns "1" since the line is enabled.

```
OUTP:ECLT1:STAT 1          ! Enable ECL Trigger bus line 1.
OUTP:ECLT1?                ! Query bus enable state.
```

OUTPut[:EXTernal][:STATe]

OUTPut[:EXTernal][:STATe] *<mode>* enables or disables the "Trig Out" port on the E1406A command module to output a trigger when a channel is closed during a scan.

- OUTPut[:EXTernal][:STATe] ON | 1 enables the port.
- OUTPut[:EXTernal][:STATe] OFF | 0 disables the port.

Parameters

Name	Type	Range of Values	Default Value
<mode>	boolean	ON | OFF | 1 | 0	OFF | 0

Comments **Enabling "Trig Out" Port:** When enabled, a pulse is output from the "Trig Out" port each time a channel is closed during scanning. If disabled, a pulse is not output from the port after channel closures.

Output Pulse: The pulse is a +5 V negative-going pulse.

"Trig Out" Port Shared by Switchboxes: Only one switchbox configuration can use the selected trigger at a time. When enabled, the "Trig Out" port may is pulsed by the switchbox each time a scanned channel is closed. To disable the output for a specific switchbox, send the OUTP OFF or 0 command for that switchbox.

One Output Selected at a Time: Only one output (ECLTrg*n*, TTLTrg*n* or EXTernal) can be enabled at one time. Enabling a different output source will automatically disable the active output. For example, if TTLTrg1 is the active output and TTLTrg4 is enabled, TTLTrg1 will become disabled and TTLTrg4 will become the active output.

Related Commands: [ROUTe:]SCAN, TRIGger:SOURce

***RST Condition:** OUTPut[:EXTernal][:STATe] OFF (port disabled).

Example

Enabling "Trig Out" Port

```
OUTP ON                  ! Enable "Trig Out" port to output pulse
                           after each scanned channel is closed.
```

OUTPut[:EXTernal][:STATe]?

OUTPut[:EXTernal][:STATe]? queries the present state of the "Trig Out" port on the E1406A command module. The command returns "1" if the port is enabled or "0" if disabled.

Example

Querying "Trig Out" Port State

```
OUTP ON                  ! Enable "Trig Out" port for pulse output.
OUTP?                    ! Query port enable state.
```

OUTPut:TTLTrg*n*[:STATe]

OUTPut:TTLTrg*n*[:STATe] <*mode*> selects and enables which TTL Trigger bus line (0 to 7) will output a trigger when a channel is closed during a scan. This command is also used to disable a selected TTL Trigger bus line. "*n*" specifies the TTL Trigger bus line (0 to 7) and <*mode*> enables (ON or 1) or disables (OFF or 0) the specified TTL Trigger bus line.

Parameters

Name	Type	Range of Values	Default Value
n	numeric	0 to 7	N/A
<*mode*>	boolean	ON | OFF | 1 | 0	OFF | 0

Comments

Enabling TTL Trigger Bus: When enabled, a pulse is output from the selected TTL Trigger bus line (0 to 7) after each channel is closed during a scan. If disabled, a pulse is not output from the selected TTL Trigger bus line after channel closures. The output is a negative-going pulse.

TTL Trigger Bus Line Shared by Switchboxes: Only one switchbox configuration can use the selected trigger at a time. When enabled, the selected TTL Trigger bus line (0 to 7) is pulsed by the switchbox each time a scanned channel is closed. To disable the output for a specific switchbox, send the OUTPut:TTLTrg*n* OFF or 0 command for that switchbox.

One Output Selected at a Time: Only one output (ECLTrg*n*, TTLTrg*n* or EXTernal) can be enabled at one time. Enabling a different output source will automatically disable the active output. For example, if TTLTrg1 is the active output and TTLTrg4 is enabled, TTLTrg1 will become disabled and TTLTrg4 will become the active output.

Related Commands: [ROUTe:]SCAN, TRIGger:SOURce, OUTPut:TTLTrg*n*[:STATe]?

***RST Condition:** OUTPut:TTLTrg*n*[:STATe] OFF (disabled)

Example — Enabling TTL Trigger Bus Line 7

OUTP:TTLT7:STAT 1	*! Enable TTL Trigger bus line 7 to output pulse after each scanned channel is closed.*

OUTPut:TTLTrg*n*[:STATe]?

OUTPut:TTLTrg*n*[:STATe]? queries the present state of the specified TTL Trigger bus line. The command returns "1" if the specified TTLTrg bus line is enabled or "0" if disabled.

Example — Querying TTL Trigger Bus Line Enable State

This example enables TTL Trigger bus line 7 and queries the enable state. The OUTPut:TTLTrg*n*? command returns "1" since the port is enabled.

OUTP:TTLT7:STAT 1	*! Enable TTL Trigger bus line 7.*
OUTP:TTLT7?	*! Query bus enable state.*

The [ROUTe:] command subsystem controls switching and scanning operations for the matrix switch modules in a switchbox. It is also used to control the 8 kB NVRAM on the PC board of the module where up to 511 state patterns can be stored.

Subsystem Syntax

```
[ROUTe:]
    CLOSe  <channel_list>
    CLOSe?  <channel_list>
    FUNCtion  <card_num>, <mode>
    FUNCtion?  <card_num
    OPEN  <channel_list>
    OPEN?  <channel_list>
    PATTern:
        ACTivate <card_num>, <pattern_num>
        ACTivate? <card_num>
        CLOSe  <channel_list>
        CLOSe?  <channel_list>
        NUMBer <card_num>, <pattern_num>
        NUMBer? <card_num>
        OPEN  <channel_list>
        OPEN?  <channel_list>
    SCAN  <channel_list>
```

[ROUTe:]CLOSe

[ROUTe:]CLOSe *<channel_list>* closes the channels specified in the *channel_list*. The *channel_list* is in the form of (@ssrrcc), where ss = card number (01-99), rr = matrix row number, and cc = matrix column number.

Parameters

Name	Type	Range of Values	Items
<channel_list>	numeric numeric numeric	01 - 99 00 - 03 00 - 31	card (ss) row (rr) column (cc)

Comments

Closing Channels: To close:

-- a single channel, use CLOS (@ssrrcc);
-- multiple channels, use CLOS (@ssrrcc,ssrrcc,...);
-- sequential channels, use CLOS (@ssrrcc:ssrrcc);
-- groups of sequential channels, use CLOS (@ssrrcc:ssrrcc;ssrrcc:ssrrcc);
-- or any combination of the above.

Closure order for multiple channels with a single command is not guaranteed. Use sequential CLOSe commands when needed.

NOTE *Channel numbers in the <channel_list> can be in any random order.*

Related Commands: [ROUTe:]OPEN, [ROUTe:]CLOSe?

***RST Condition:** All channels are open.

Example **Closing Multiple Channels**

This example closes channels 10101 and 10201 of a single-module switchbox.

```
CLOS (@10101,10201)                    ! Close relays on row 01, column 01
                                         and row 02, column 01 of the module.
```

[ROUTe:]CLOSe?

[ROUTe:]CLOSe? *<channel_list>* returns the current state of the channel(s) queried. The *channel_list* is in the form of (@ssrrcc). The command returns "1" if the channel is closed or returns "0" if the channel is open. If a list of channels is queried, a comma delineated list of 0 or 1 values is returned in the same order of the channel list.

Comments **Query is Software Readback:** The ROUTe:CLOSe? command returns the current software state of the channel(s) specified. It does not account for relay hardware failures.

***Channel_list* Definition:** See "[ROUTe:]CLOSe" on page 70 for the channel_list definition.

NOTE *A maximum of 128 channels can be queried at one time. Therefore, if you want to query more than 128 channels, you must enter the query data in two separate commands.*

Example **Querying Channel Closure States**

This example closes channels 10101 and 10201 of a single-module switchbox and queries channel closure. Since the channels are programmed to be closed, "1,1" is returned.

```
CLOS (@10101,10201)                    ! Close relays on row 01, column 01
                                         and on row 02, column 01 of the
                                         module.
CLOS? (@10101,10201)                   ! Query channels closure state.
```

[ROUTe:]FUNCtion

[ROUTe:]FUNCtion *<card_num>, <mode>* configures the specified module either as a 4x32 matrix or as two independent 4x16 matrixes. The E8481A module is configured as a 4x32 matrix module at the factory.

Parameters

Name	Type	Range of Values	Default Value
<card_num>	numeric	01 - 99	N/A
<mode>	Discrete	SINGLE4X32 | DUAL4X16	SINGLE4X32

Comments

Using the Command: The module remains in the specified function mode at power-up/down or after a reset. Executing [ROUTe:]FUNCtion command to change the mode.

After Changing Function Mode: Once the function mode is changed, all channel relays on the module will be open.

Related Commands: [ROUTe:]FUNCtion?

Example

Configuring Module Function Mode

This example configures the module #1 to function as two independent 4x16 matrixes.

```
FUNC 1, DUAL4X16                ! Configure module #1 as two
                                  independent 4x16 matrixes.
```

[ROUTe:]FUNCtion?

[ROUTe:]FUNCtion? *<card_num>* returns the current function mode of the specified module. "SINGLE4X32" returned indicates the module is configured as a 4x32 Matrix and "DUAL4X16" indicates the module is configured as two independent 4x16 matrixes.

Parameters

Name	Type	Range of Values	Default Value
<card_num>	numeric	01 - 99	N/A

Comments

Related Commands: [ROUTe:]FUNCtion

Example

Querying Module Function Mode

This example configures the module #1 as a 4x32 Matrix, then queries the setting.

```
FUNC 1, SINGLE4X32              ! Configure module #1 as a 4x32 Matrix.
FUNC? 1                         ! SINGLE4X32 returned indicates the
                                  module functions as an 4x32 matrix.
```

[ROUTe:]OPEN

[ROUTe:]OPEN ***<channel_list>*** opens the channels specified in the *channel_list*. The *channel_list* is in the form of (@ssrrcc), where ss = card number (01-99), rr = matrix row number, and cc = matrix column number.

Parameters

Name	Type	Range of Values	Items
<channel_list>	numeric numeric numeric	01 - 99 00 - 03 00 - 31	card (ss) row (rr) column (cc)

Comments

Opening Channels: To open:

-- a single channel, use OPEN (@ssrrcc);
-- multiple channels, use OPEN (@ssrrcc,ssrrcc,...);
-- sequential channels, use OPEN (@ssrrcc:ssrrcc);
-- groups of sequential channels, use OPEN (@ssrrcc:ssrrcc;ssrrcc:ssrrcc);
-- or any combination of the above.

Opening order for multiple channels with a single command is not guaranteed.

Related Commands: [ROUTe:]CLOSe, [ROUTe:]OPEN?

***RST Condition:** All channels are open.

Example

Opening Multiple Channels

This example opens channels 10101 and 10201 of a single-module switchbox.

```
OPEN (@10101,10201)        ! Open relays on row 01, column 01
                             and on row 02, column 01 of the
                             module.
```

[ROUTe:]OPEN?

[ROUTe:]OPEN? ***<channel_list>*** returns the current state of the channel(s) queried. The *channel_list* is in the form of (@ssrrcc). The command returns "1" if channel(s) are open or returns "0" if channel(s) are closed. If a list of channels is queried, a comma delineated list of 0 or 1 values is returned in the same order of the channel list.

Comments

Query is Software Readback: The ROUTe:OPEN? command returns the current software state of the channel(s) specified. It does not account for relay hardware failures.

***Channel_list* Definition:** See [ROUTe:]OPEN command on page 73 for the channel_list definition.

NOTE *A maximum of 128 channels can be queried at one time. Therefore, if you want to query more than 128 channels, you must enter the query data in two separate commands.*

Example **Querying Channel Open States**

This example opens channels 10101 and 10201 of a single-module switchbox and queries channel 10201 state. Since channel 10201 is programmed to be open, "1" is returned.

OPEN (@10101,10201)	*! Open relays on row 01, column 01 and on row 02, column 01 of the module.*
OPEN? (@10201)	*! Query channel open state.*

[ROUTe:]PATTern:ACTivate

[ROUTe:]PATTern:ACTivate *<card_num>, <pattern_num>* is used to operate the channel relays with the specified state pattern previously stored in the non-volatile RAM (NVRAM) of the module. See Page 107 of this manual for more details of the state patterns in the NVRAM.

Parameters

Name	Type	Range of Values	Default value
<card_num>	numeric	01 - 99	N/A
<pattern_num>	numeric	0 - 510	N/A

Comments This command consists of a series of data fetching from the specified NVRAM address space, then expanding and putting these data into the corresponding Relay Control Registers. The module will set the BUSY bit of the Status/Control Register to "1" during the whole operation, and set the BUSY bit to "0" after all the relays are stable.

Using this command for switching: Switching all 128 channels of the module is almost as fast as switching a single channel.

Related Commands: [ROUTe:]PATTern:OPEN, [ROUTe:]PATTern:CLOSe, [ROUTe:]PATTern:ACTivate?

Example **Using State Pattern to Switch Channels**

This example recalls the previously stored Pattern 10 to operate channel relays of module #1.

PATT:ACT 1, 10	*! Recall state pattern 10 to operate channel relays of the module #1.*

[ROUTe:]PATTern:ACTivate?

[ROUTe:]PATTern:ACTivate? *<card_num>* returns the pattern number set by the PATTern:ACTivate command. The returned value should be between 0 and 510. See Page 107 of this manual for more details on the pattern structure in the NVRAM of the module.

Parameters

Name	Type	Range of Values	Default value
<card_num>	numeric	01 - 99	N/A

Comments

Related Commands: [ROUTe:]PATTern:ACTivate

Example

Querying Which Pattern is Activated

This example uses state pattern 10 to operate all channels of the module #1, then verify which pattern is being loaded.

```
PATT:ACT 1, 10        ! Recall pattern 10 data to operate
                        channel relays of the module #1.
PATT:ACT? 1           ! Query which pattern is being loaded.
                        "10" is returned.
```

[ROUTe:]PATTern:CLOSe

[ROUTe:]PATTern:CLOSe *<channel_list>* is used to set the specified channel(s) to the closed state in the state pattern of the module's NVRAM. Before setting, you must use PATT:NUMB command to select a pattern number (0-510) for storing. This command does not really close the specified channel relays. To operate channel relays with the stored state pattern, use PATT:ACT command. For more information about the state patterns in the NVRAM, see Page 107 of this manual. The *channel_list* is in the form of (@*ssrrcc*), where *ss* = card number (01-99), *rr* = matrix row number, and *cc* = matrix column number.

NOTE *This command only changes the specified channels state in the selected pattern and does not affect other channel states of the pattern. Once the channel states are stored in a pattern, they will not change at power-on or reset. As a consequence, the user should be aware of the pattern's previous value when editing.*

Parameters

Name	Type	Range of Values	Items
<channel_list>	numeric numeric numeric	01 - 99 00 - 03 00 - 31	card (ss) row (rr) column (cc)

Comments Specifying channels to be stored as open state in NVRAM pattern:

-- Use PATT:CLOSe (@ssrrcc) for a single channel;
-- Use PATT:CLOSe (@ssrrcc,ssrrcc,...) for multiple channels;
-- Use PATT:CLOSe (@ssrrcc:ssrrcc) for sequential channels;
-- Use PATT:CLOSe (@ssrrcc:ssrrcc;ssrrcc:ssrrcc) for groups of sequential channels;
-- or any combination of the above.

This command only changes the specified channel states stored in the state pattern of the NVRAM. It does not really close the specified channel relays. Use PATT:ACT command to operate channel relays with the stored state pattern.

Related Commands: [ROUTe:]PATT:ACT, [ROUTe:]PATT:NUMB

Example **Setting Channels to the Closed States in Pattern 1**

This example sets channels 10101 and 10201 to the closed state in Pattern 1.

PATT:NUMB 1, 1	*! Select State Pattern 1 of Module #1 for editing.*
PATT:CLOS (@10101,10201)	*! Set channels 10101 and 10201 to the closure state in pattern 1.*

[ROUTe:]PATTern:CLOSe?

[ROUTe:]PATTern:CLOSe? <*channel_list*> returns the state of the specified channel(s) stored in the state pattern of the module's NVRAM. You must use PATT:NUMB command to select a pattern to be queried first. The command returns "1" if the channel state in the NVRAM pattern is closed or returns "0" if open. If a list of channels is queried, a comma delineated list of 0 or 1 values is returned in the same order of the channel list. See Page 107 of this manual for more details on the pattern structure in the module's NVRAM.

Comments ***Channel_list* definition**: See [ROUTe:]PATT:CLOSe for its definition.

NOTE *A maximum of 128 channels can be queried at one time. Therefore, if you want to query more than 128 channels, you must enter the query data in two separate commands.*

Example **Querying Channels Closure State Stored in Pattern 1**

This example sets channels 10101 and 10201 to the closure state in state pattern 1, then queries the setting.

PATT:NUMB 1, 1	*! Select Pattern 1 of Module #1 to be written to.*
PATT:CLOS (@10101,10201)	*! Set the channels 10101 and 10201 to closure state in pattern 1.*
PATT:CLOS? (@10101,10201)	*! "1,1" will be returned.*

[ROUTe:]PATTern:NUMBer

[ROUTe:]PATTern:NUMBer *<card_num>, <pattern_num>* selects a state pattern in the module's NVRAM to store the channels state. See Page 107 of this manual for more details on the pattern structure in the module's NVRAM.

Parameters

Name	Type	Range of Values	Default value
<card_num>	numeric	01 - 99	N/A
<pattern_num>	numeric	0 - 510	0

Comments

Using This Commands: This command is often used before setting channel states in a state pattern with PATT:CLOS or PATT:OPEN command.

Related Commands: [ROUTe:]PATT:CLOSe, [ROUTe:]PATT:OPEN

Example

Selecting Pattern 1 in the NVRAM of Module #1 for Editing

```
PATT:NUMB 1, 1                    ! Select Pattern 1 of Module #1 to
                                    store channels state.
```

[ROUTe:]PATTern:NUMBer?

[ROUTe:]PATTern:NUMBer? *<card_num>* returns the current pattern number set by PATT:NUMB. The returned value should be between 0 and 510. See Page 107 of this manual for more details on the pattern structure in the module's NVRAM.

Parameters

Name	Type	Range of Values	Default value
<card_num>	numeric	1 - 99	N/A

Comments

Related Commands: [ROUTe:]PATTern:NUMBer

Example

Querying Which Pattern is Selected for Editing

This example selects state pattern 10 in the NVRAM of module #1 for editing, then queries the setting.

```
PATT:NUMB 1, 10                   ! Select pattern 10 of the module #1
                                    to be written to.
PATT:NUMB? 1                      ! "10" is returned.
```

[ROUTe:]PATTern:OPEN

[ROUTe:]PATTern:OPEN *<channel_list>* is used to set the specified channel(s) to the open state in the state pattern of the module's NVRAM. Before setting, you must use PATT:NUMB command to select a pattern number (0-510). This command does not really open the specified channel relays. To operate channel relays with the stored state pattern, use PATT:ACT command. For more information about the state patterns in the NVRAM, see Page 107 of this manual. The *channel_list* is in the form of (@ssrrcc), where ss = card number (01-99), rr = matrix row number, and cc = matrix column number.

NOTE *This command only changes the specified channels state in the selected pattern and does not affect other channel states of the pattern. Once the channel states are stored in a pattern, they will not change at power-on or reset. As a consequence, the user should be aware of the pattern's previous value when editing.*

Parameters

Name	Type	Range of Values	Items
<channel_list>	numeric numeric numeric	01 - 99 00 - 03 00 - 31	card (ss) row (rr) column (cc)

Comments

Specifying channels to be stored as the open state in NVRAM pattern:

-- Use PATT:OPEN (@ssrrcc) for a single channel;
-- Use PATT:OPEN (@ssrrcc,ssrrcc,...) for multiple channels;
-- Use PATT:OPEN (@ssrrcc:ssrrcc) for sequential channels;
-- Use PATT:OPEN (@ssrrcc:ssrrcc;ssrrcc:ssrrcc) for groups of sequential channels;
-- or any combination of the above.

This command only changes the specified channel states stored in the state pattern of the NVRAM. It does not really open the specified channel relays. Use PATT:ACT command to operate channel relays with the stored state pattern.

Related Commands: [ROUTe:]PATT:ACT, [ROUTe:]PATT:NUMB

***RST Condition:** All channels are open.

Example

Setting Channels to Open States in Pattern 1

This example sets channels 10101 and 10201 to the open state in state pattern 1.

PATT:NUMB 1, 1	*! Select Pattern 1 of Module #1 to be edited.*
PATT:OPEN (@10101,10201)	*! Set channels 10101 and 10201 to the open states in pattern 1.*

[ROUTe:]PATTern:OPEN?

[ROUTe:]PATTern:OPEN? <*channel_list*> returns the state of the specified channel(s) stored in the state pattern of the module's NVRAM. You must use PATT:NUMB command to select a pattern to be queried first. The command returns "1" if the channel state in the NVRAM pattern is open or returns "0" if closed. If a list of channels is queried, a comma delineated list of 0 or 1 values is returned in the same order of the channel list. For more information about the state patterns in the module's NVRAM, see Page 107 of this manual.

Comments ***Channel_list* Definition:** See [ROUTe:]PATT:OPEN for its definition.

NOTE *A maximum of 128 channels can be queried at one time. Therefore, if you want to query more than 128 channels, you must enter the query data in two separate commands.*

Example **Querying Channel Open States Stored in NVRAM Pattern**

This example sets channels 10101 and 10201 to the open state in Pattern 1, then queries the setting.

PATT:NUMB 1, 1	*! Select Pattern 1 of Module #1 to store channels state.*
PATT:OPEN (@10101,10201)	*! Set channels 10101 and 10201 to the open state in pattern 1.*
PATT:OPEN? (@10101,10201)	*! "1,1" will be returned.*

[ROUTe:]SCAN

[ROUTe:]SCAN *<channel_list>* defines the channels to be scanned. The *channel_list* is in the form of (@ssrrcc), where ss = card number (01-99), rr = matrix row number, and cc = matrix column number.

Parameters

Name	Type	Range of Values	Items
<channel_list>	numeric numeric numeric	01 - 99 00 - 03 00 - 31	card (ss) row (rr) column (cc)

Comments

Defining Scan List: When ROUTe:SCAN is executed, the channel list is checked for valid card and channel numbers. An error is generated for an invalid channel list.

Scanning Channels: To scan:

-- a single channel, use SCAN (@ssrrcc);
-- multiple channels, use SCAN (@ssrrcc,ssrrcc,...);
-- sequential channels, use SCAN (@ssrrcc:ssrrcc);
-- groups of sequential channels, use SCAN (@ssrrcc:ssrrcc;ssrrcc:ssrrcc);
-- or any combination of the above.

Scanning Operation: When a valid channel list is defined, INITiate[:IMMediate] begins the scan and closes the first channel in the *channel_list*. Successive triggers from the source specified by TRIGger:SOURce advance the scan through the channel list. At the end of the scan, the last trigger opens the last channel.

Stopping Scan: See ABORt command on page 56.

Related Commands: TRIGger, TRIGger:SOURce

***RST Condition:** All channels are open.

Example

Scanning Channels Using External Triggers

This example uses external triggering (TRIG:SOUR EXT) to scan channels 10000 through 10003 of a single-module switchbox. The trigger source to advance the scan is the input to the "Trig In" on the E1406A command module. When INIT is executed, the scan is started and channel 0000 is closed. Then, each trigger received at the "Trig In" port advances the scan to the next channel.

```
TRIG:SOUR  EXT              ! Set trigger source to external.
SCAN  (@10000:10003)        ! Set channel list to be scanned.
INIT                        ! Start scanning cycle and close
                              channel 10000.
(trigger externally)        ! Advance scan to next channel.
```

The **STATus** subsystem reports the bit values of the Operation Status Register. It also allows you to unmask the bits you want reported from the Standard Event Register and to read the summary bits from the Status Byte Register.

Subsystem Syntax

```
STATus
    :OPERation
        :CONDition?
        :ENABle  <unmask>
        :ENABle?
        [:EVENt]?
    :PRESet
```

The STATus system contains four registers (that is, they reside in a SCPI driver, not in the hardware), two of which are under IEEE 488.2 control; the Standard Event Status Register (*ESE?) and the Status Byte Register (*STB?). The Operational Status bit (OPR), Service Request bit (RQS), Standard Event Summary bit (ESB), Message Available bit (MAV) and Questionable Data bit (QUE) in the Status Byte Register (bits 7, 6, 5, 4 and 3 respectively) can be queried with the *STB? command. Use the *ESE? command to query the *<unmask>* value for the Standard Event Status Register (the bits you want logically OR'd into the summary bit). The registers are queried using decimal weighted bit values. The decimal equivalents for bits 0 through 15 are included in Figure 4-1 on page 82.

A numeric value of 256 executed in a STATus:OPERation:ENABle *<unmask>* command allows only bit 8 to generate a summary bit. The decimal value for bit 8 is 256.

The decimal values are also used in the inverse manner to determine which bits are set from the total value returned by an EVENt or CONDition query. The relay matrix module driver exploits only bit 8 of Operation Status Register. This bit is called the scan complete bit which is set whenever a scan operation completes. Since completion of a scan operation is an event in time, you will find that bit 8 will never appear set when STATus:OPERation:CONDition? is queried. However, you can find bit 8 set with the STATus:OPERation:EVENt? query command.

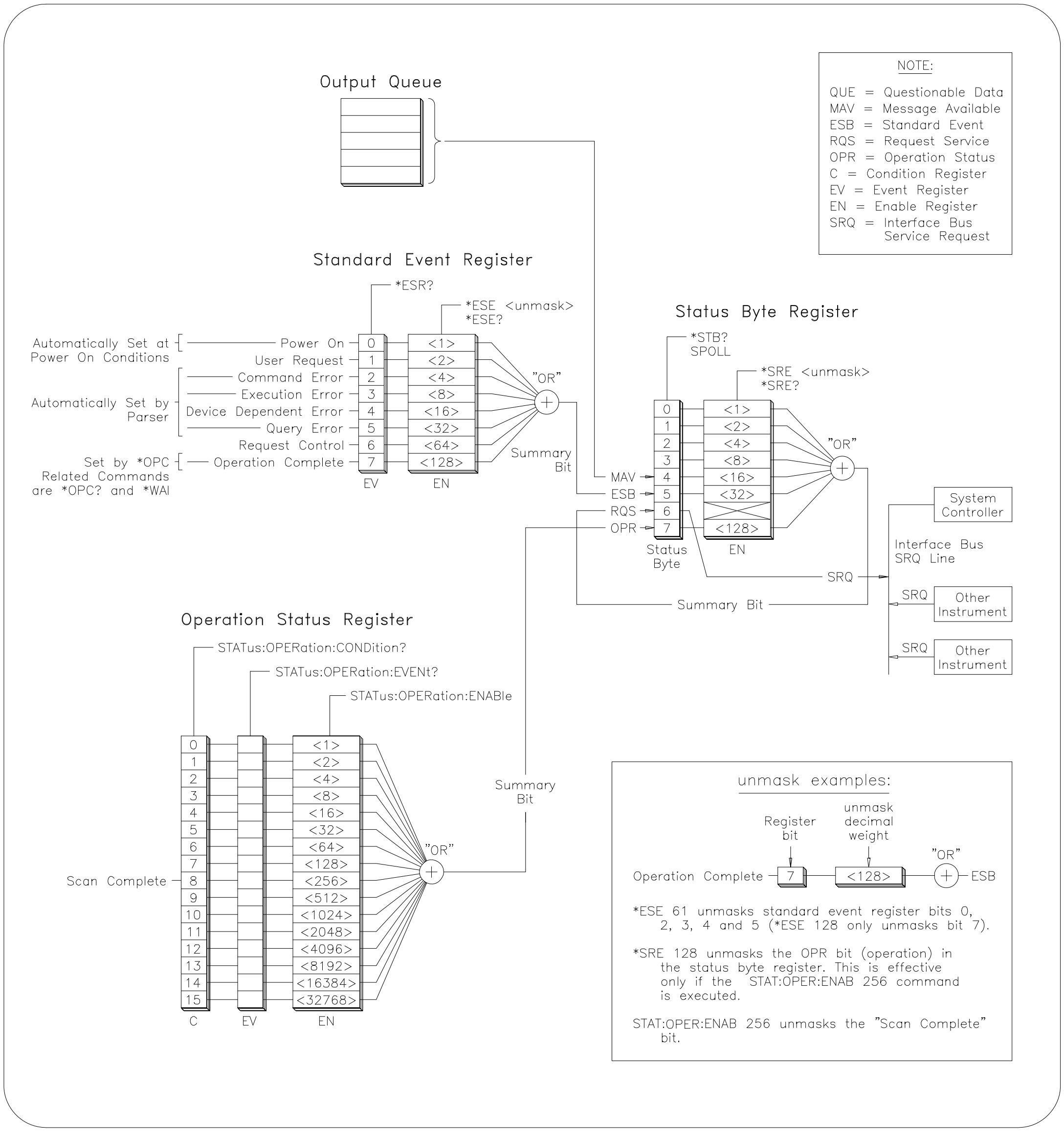


Figure 4-1. E8481A Status System Register Diagram

STATus:OPERation:CONDition?

STATus:OPERation:CONDition? returns the state of the Condition Register in the Operation Status Group. The state represents conditions which are part of the instrument's operation. The module's driver does not set bit 8 in this register (see STATus:OPERation[:EVENt]?).

STATus:OPERation:ENABle

STATus:OPERation:ENABle ***<unmask>*** sets an enable mask to allow events recorded in the Event Register (Operation Status Group) to send a summary bit to the Status Byte Register (bit 7). For the matrix module, when bit 8 in the Operation Status Register is set to "1" and that bit is enabled by the STATus:OPERation:ENABle 256 command, bit 7 in the Status Byte Register is set to "1".

Parameters

Name	Type	Range of Values	Default Value
<unmask>	numeric	0 - 65,535	N/A

Comments

Setting Bit 7 of the Status Byte Register: STATus:OPERation:ENABle 256 sets bit 7 of the Status Byte Register to "1" after bit 8 of the Operation Status Register is set to "1".

Related Commands: [ROUTe:]SCAN

Example

Enabling Operation Status Register Bit 8

```
STAT:OPER:ENAB 256          ! Enable bit 8 of the Operation Status
                              Register to be reported to bit 7 (OPR)
                              in the Status Byte Register.
```

STATus:OPERation:ENABle?

STATus:OPERation:ENABle? returns which bits in the Event Register (Operation Status Group) are unmasked.

Comments

Output Format: Returns a decimal weighted value from 0 to 65,535 indicating which bits are set to true.

Maximum Value Returned: The value returned is the value set by the STAT:OPER:ENAB *<unmask>* command. However, the maximum decimal weighted value used in this module is 256 (bit 8 set to true).

Example

Querying the Operation Status Enable Register

```
STAT:OPER:ENAB?             ! Query the Operation Status Enable
                              Register.
```

STATus:OPERation[:EVENt]?

STATus:OPERation[:EVENt]? returns which bits in the Event Register (Operation Status Group) are set. The Event Register indicates when there has been a time-related instrument event.

Comments

Setting Bit 8 of the Operation Status Register: Bit 8 (scan complete) is set to "1" after a scanning cycle completes. Bit 8 returns to "0" after sending the STATus:OPERation[:EVENt]? command.

Returned Data after sending the STATus:OPERation[:EVENt]? Command: The command returns "+256" if bit 8 of the Operation Status Register is set to "1". The command returns "+0" if bit 8 of the Operation Status Register is set to "0".

Event Register Cleared: Reading the Event Register with the STATus:OPERation:EVENt? command clears it.

Aborting a Scan: Aborting a scan will leave bit 8 set to 0.

Related Commands: [ROUTe:]SCAN

Example

Reading Operation Status Register After a Scanning Cycle

```
STAT:OPER?                ! Return the bit values of the Operation
                            Status Register. "+256" returned shows
                            bit 8 is set to 1; "+0" shows
                            bit 8 is set to 0.
```

STATus:PRESet

STATus:PRESet affects only the Enable Register by setting all Enable Register bits to 0. It does not affect either the "status byte" or the "standard event status". PRESet does not clear any of the Event Registers.

The **SYSTem** subsystem returns the error numbers and error messages in the error queue of a matrix module. It can also return the types and descriptions of modules in a switchbox.

Subsystem Syntax

```
SYSTem
    :CDEScription? <card_number>
    :CPON  <card_number> | ALL
    :CTYPe?  <card_number>
    :ERRor?
    :VERSion?
```

SYSTem:CDEScription?

SYSTem:CDEScription? *<card_number>* returns the description of a selected module in a switchbox.

Parameters

Name	Type	Range of Values	Default Value
<card_number>	numeric	1 - 99	N/A

Comments

Module Description: The SYSTem:CDEScription? *<card_number>* command returns:

```
"Dual Wire 4 x 32 Matrix Switch"
```

Example

Reading the Description of Module #1

SYST:CDES? 1 *! Return the description of module #1.*

SYSTem:CPON

SYSTem:CPON *<card_number>* | ALL resets the selected module, or multiple modules in a switchbox.

Parameters

Name	Type	Range of Values	Default Value
<card_number>	numeric	1 - 99 or ALL	N/A

Comments

Module Power-on State: The power-on state of the module is all channels (relays) open. Note that SYSTem:CPON ALL and *RST opens all channels of all modules in a switchbox, while SYSTem:CPON *<number>* opens the channels in only the module specified in the command.

Example **Setting Module #1 to its Power-on State**

```
SYST:CPON 1    ! Set module #1 to its power-on state
               (All channels are open).
```

SYSTem:CTYPe?

SYSTem:CTYPe? *<card_number>* returns the module type of a selected module in a switchbox.

Parameters

Name	Type	Range of Values	Default Value
<card_number>	numeric	1 - 99	N/A

Comments

Agilent E8481A Module Model Number: Sending this command returns:

```
HEWLETT-PACKARD,E8481A,<10-digit number>,A.11.01
```

where the <10-digit number> is the module's serial number and A.11.01 is an example of the module revision code number.

NOTE *The <10-digit number> returns 0 (zero) if the checksum of the serial EEPROM on the module has error.The checksum of the EEPROM on the module is always checked each time the* SYST:CTYP? <number> *command is executed. Refer to DIAGnostic:TEST:SEEProm? command on page 61 for details.*

Related Commands: DIAG:TEST:SEEProm? *<card_number>*

Example **Reading the Model Number of Module #1**

```
SYST:CTYP? 1    ! Return the model number of module #1.
```

SYSTem:ERRor?

SYSTem:ERRor? returns the error numbers and corresponding error messages in the error queue of a matrix module. See Appendix C for a listing of the module error numbers and messages.

Comments

Error Numbers/Messages in the Error Queue: Each error generated by a matrix module stores an error number and corresponding error message in the error queue. The error message can be up to 255 characters long.

Clearing the Error Queue: An error number/message is removed from the queue each time the SYSTem:ERRor? command is sent. The errors are cleared first-in, first-out. When the queue is empty, each following SYSTem:ERRor? command returns: +0, "No error". To clear all error numbers/messages in the queue, execute the *CLS command.

Maximum Error Numbers/Messages in the Error Queue: The queue holds a maximum of 30 error numbers/messages for each switchbox. If the queue overflows, the last error number/message in the queue is replaced by: -350, "Too many errors". The least recent (oldest) error numbers/messages remain in the queue and the most recent are discarded.

Example **Reading the Error Queue**

```
SYST:ERR?                    ! Query the error queue.
```

SYSTem:VERSion?

SYSTem:VERSion? returns the version of the SCPI standard to which this instrument complies.

Comments **SCPI Version:** This command always returns a decimal value "1990.0", where "1990" is the year, and "0" is the revision number within that year.

Example **Reading SCPI Version**

```
SYST:VERS?                   ! Read the version of the SCPI standard.
```

The **TRIGger** subsystem controls the triggering operation of the matrix switch modules in a switchbox.

Subsystem Syntax

```
TRIGger
    [:IMMediate]
    :SOURce <source>
    :SOURce?
```

TRIGger[:IMMediate]

TRIGger[:IMMediate] causes a trigger event to occur when the defined trigger source is TRIGger:SOURce BUS or TRIGger:SOURce HOLD. This can be used to trigger a suspended scan operation.

Comments

Executing This Command: A channel list must be defined with [ROUTe:]SCAN <*channel_list*> and an INITiate[:IMMediate] command must be executed before TRIGger[:IMMediate] will execute.

BUS or HOLD Source Remains: If selected, the TRIGger:SOURce BUS or TRIGger:SOURce HOLD commands remain in effect after triggering a switchbox with the TRIGger[:IMMediate] command.

Related Commands: INITiate, [ROUTe:]SCAN, TRIGger:SOURce

Example

Advancing Scan Using TRIGger Command

This example uses the TRIGger command to advance the scan of a single-module switchbox from channel 10000 through 10003. Since TRIGger:SOURce HOLD is set, the scan is advanced one channel each time TRIGger is executed.

```
TRIG:SOUR HOLD            ! Set trigger source to HOLD.
SCAN (@10000:10003)       ! Define channel list to be scanned.
INIT                      ! Start scanning cycle, close channel 100.
loop statement            ! Start count loop.
TRIG                      ! Advance scan to next channel.
increment loop            ! Increment loop count.
```

TRIGger:SOURce

TRIGger:SOURce ***<source>*** specifies the trigger source to advance the channel list during scanning.

Parameters

Name	Type	Parameter Description
BUS	discrete	*TRG or GET or TRIGger[:IMMediate] command
ECLTrg*n*	numeric	ECL Trigger bus line 0 - 1
EXTernal	discrete	"Trig In" port
HOLD	discrete	Hold Triggering until receiving *TRG command.
IMMediate	discrete	Immediate Triggering
TTLTrg*n*	numeric	TTL Trigger bus line 0 - 7

Comments

Enabling the Trigger Source: The TRIGger:SOURce command only selects the trigger source. The INITiate[:IMMediate] command enables the trigger source. The trigger source must be selected with TRIGger:SOURce command before executing the INIT command.

Using Bus Triggers: To trigger the switchbox with TRIGger:SOURce BUS selected, use the IEEE 488.2 common command *TRG or the GPIB Group Execute Trigger (GET) command, or SCPI command TRIGger[:IMMediate].

One Trigger Input Selected at a Time: Only one input (ECLTrg0 or 1; TTLTrg0, 1, 2, 3, 4, 5, 6 or 7; or EXTernal) can be selected at one time. Enabling a different trigger source will automatically disable the active input. For example, if TTLTrg1 is the active input, and TTLTrg4 is enabled, TTLTrg1 will become disabled and TTLTrg4 will become the active input.

Using TTL or ECL Trigger Bus Inputs: These triggers are from the VXI backplane trigger lines ECL[0,1] and TTL[0-7]. These may be used to trigger the "SWITCH" driver from other VXI instruments.

Using External Trigger Inputs: With TRIGger:SOURce EXTernal selected, only one switchbox at a time can use the external trigger input at the E1406A "Trig In" port. The trigger input is assigned to the first switchbox requesting the external trigger source (with a TRIGger:SOURce EXTernal command).

Assigning EXTernal, TTLTrgn, and ECLTrgn Trigger Inputs: After using TRIGger:SOURce EXT|TTLT*n*|ECLT*n*, the selected trigger source remains assigned to the "SWITCH" driver until it is relinquished through use of the TRIG:SOUR BUS|HOLD command. While the trigger is in use by the "SWITCH" driver, no other drivers operating on the E1406A command module will have access to that particular trigger source. Likewise, other drivers may consume trigger resources which may deny access to a particular trigger by the "SWITCH" driver.

When Trigger Source is HOLD: You can use TRIGger[:IMMediate] command to advance the scan when TRIGger:SOURce HOLD is selected.

"Trig Out" Port Shared by Switchboxes: See the “OUTPut” on page 66 for more information.

Related Commands: ABORt, [ROUTe:]SCAN, OUTPut

***RST Condition:** TRIGger:SOURce IMMediate

Example **Scanning Using External Triggers**

This example uses external triggering (TRIG:SOUR EXT) to scan channels 10000 through 10003 of a single-module switchbox. The trigger source to advance the scan is the input to the "Trig In" on the E1406A command module. When INIT is executed, the scan is started and channel 0000 is closed. Then, each trigger received at the "Trig In" port advances the scan to the next channel.

```
TRIG:SOUR  EXT                 ! Set trigger source to external.
SCAN  (@10000:10003)           ! Set channel list to be scanned.
INIT                           ! Start scanning cycle and close
                                 channel 10000.
(trigger externally)           ! Advance scan to next channel.
```

Example **Scanning Using Bus Triggers**

This example uses bus triggering (TRIG:SOUR BUS) to scan channels 10000 through 10003 of a single-module switchbox. The trigger source to advance the scan is the *TRG command (as set with TRIGger:SOURce BUS). When INIT is executed, the scan is started and channel 10000 is closed. Then, each *TRG command advances the scan to the next channel.

```
TRIG:SOUR  BUS                 ! Set trigger source to bus.
SCAN  (@10000:10003)           ! Set channel list to be scanned.
INIT                           ! Start scanning cycle and close
                                 channel 10000.
loop statement                 ! Loop to scan all channels.
*TRG                           ! Advance scan to next channel.
Increment loop                 ! Increment loop count.
```

TRIGger:SOURce?

TRIGger:SOURce? returns the current trigger source for the switchbox. Command returns: BUS, EXT, HOLD, IMM, ECLT0-1, or TTLT0-7 for sources BUS, EXTernal, HOLD, IMMediate, ECLTrg*n*, or TTLTrg*n*, respectively.

Example **Querying Trigger Source**

This example sets external triggering and queries the trigger source. Since external triggering is set, TRIG:SOUR? returns "EXT".

```
TRIG:SOUR  EXT                 ! Set external trigger source.
TRIG:SOUR?                     ! Query trigger source.
```

SCPI Command Quick Reference

The following table summarizes the SCPI commands for the E8481A Module.

Command		Description
ABORt	ABORt	Abort a scan in progress.
ARM	:COUNt <*number*> | MIN | MAX :COUNt? [MIN | MAX]	Multiple scans per INIT command. Query number of scans.
DIAGnostic	:INTerrupt[:LINe] <*card_num*>,<*line_num*> :INTerrupt[:LINe]? <*card_num*> :TEST[:RELays]? :TEST:EEPRom? <*card_num*>	Set an interrupt line for the specified module. Query the interrupt line of the specified module. Do diagnostic to find the specific error(s). Check the integrity (checksum) of EEPROM on the specified module.
DISPlay	:MONitor:CARD <*card_num*> | AUTO :MONitor:CARD? :MONitor[:STATe] <*mode*> :MONitor[:STATe]?	Select a module in a switchbox to be monitored. Query which module is set by above command. Set the monitor state on or off. Query the monitor state setting.
INITiate	:CONTinuous ON | OFF :CONTinuous? [:IMMediate]	Enables/disables continuous scanning. Query continuous scan state. Starts a scanning cycle.
OUTPut	:ECLTrgn[:STATe] ON | OFF | 1 | 0 :ECLTrgn[:STATe]? [:EXTernal][:STATe] ON | OFF | 1 | 0 [:EXTernal][:STATe]? :TTLTrgn[:STATe] ON |OFF | 1 | 0 :TTLTrgn[:STATe]?	Enable/disable the specified ECL trigger line pulse. Query the specified ECL trigger line state. Enable/disable the "Trig Out" port on the command module. Query the "Trig Out" port enable state. Enable/disable the specified TTL trigger line pulse. Query the specified TTL trigger line state.
[ROUTe:]	CLOSe <*channel _list*> CLOSe? <*channel _list*> FUNCtion <*card_num*>, <*mode*> FUNCtion? <*card_num*> OPEN <*channel_list*> OPEN? <*channel _list*> PATTern:ACTivate <*card_num*>,<*patt_num*> PATTern:ACTivate? <*card_num*> PATTern:CLOSe <*channel _list*> PATTern:CLOSe? <*channel _list*> PATTern:NUMBer <*card_num*>,<*patt_num*> PATTern:NUMBer? <*card_num*> PATTern:OPEN <*channel _list*> PATTern:OPEN? <*channel _list*> SCAN <*channel_list*>	Close channel(s). Query channel(s) closed. Set the module function mode: single 4x32 matrix or dual 4x16 maîtres. Query the current function mode of the specified module. Open channel(s). Query channel(s) opened. Load the specified pattern into registers to operate relays. Query which pattern is loaded into the register currently. Set the channels to the closed states in the selected pattern. Query the specified channels state stored in the selected pattern. Select a pattern number to store channels state. Query which pattern is selected to store channels state currently. Set channels to the open state in the selected pattern. Query the specified channels state stored in the selected pattern. Define channels to be scanned.
STATus	:OPERation:CONDition? :OPERation:ENABle <*unmask*> :OPERation:ENABle? :OPERation[:EVENt]? :PRESet	Returns contents of the Operation Condition Register. Enables events in the Operation Event Register to be reported. Returns the unmask value set by the :ENABle command. Returns the contents of the Operation Event Register. Sets all Enable Register bits to 0.
SYSTem	:CDEScription? <*number*> :CPON <*number*> | ALL :CTYPe? <*number*> :ERRor? :VERSion?	Returns description of module. Open all channels on the specified module(s). Returns the module type. Returns error number/message in the error queue. Returns the version of the SCPI standard.

Command		Description
TRIGger	[:IMMediate] :SOURce BUS :SOURce EXTernal :SOURce HOLD :SOURce IMMediate :SOURce TTLTrg*n* :SOURce?	Causes a trigger to occur. Trigger source is *TRG. Trigger source is "Trig In" port on the E1406A. Hold off triggering. Trigger source is the internal triggers. Trigger is the VXIbus TTL trigger bus line *n* (0-7). Query scan trigger source.

IEEE 488.2 Common Command Reference

The following table lists the IEEE 488.2 Common (*) Commands that can be accepted by the matrix module.

Command	Command Description
*CLS	Clears all status registers (see STATus:OPERation[:EVENt]?) and clears the error queue.
*ESE *<unmask>*	Enable Standard Event.
*ESE?	Enable Standard Event Query.
*ESR?	Standard Event Register Query.
*IDN?	Instrument ID Query; returns identification string of the module.
*OPC	Operation Complete.
*OPC?	Operation Complete Query.
*RCL *<numeric state>*	Recalls the instrument state saved by *SAV. You must reconfigure the scan list.
*RST	Resets the module. Opens all channels and invalidates current channel list for scanning. Sets ARM:COUN 1, TRIG:SOUR IMM, and INIT:CONT OFF.
*SAV *<numeric state>*	Stores the instrument state but does not save the scan list.
*SRE *<register value>*	Service request enable, enables status register bits.
*SRE?	Service request enable query.
*STB?	Read status byte query.
*TRG	Triggers the module to advance the scan when scan is enabled and trigger source is TRIGger:SOURce BUS.
*TST?	Self-test. Executes an internal self-test and returns only the first error encountered. Does not return multiple errors. The following is a list of responses you can obtain where "cc" is the card number with the leading zero deleted. +0 if self test passes. +cc01 for firmware error. +cc02 for bus error (problem communicating with the module). +cc03 for incorrect ID information read back from the module's ID register. +cc05 for hardware and firmware have different values. Possibly a hardware fault or an outside entity is register programming the E8481A. +cc10 if an interrupt was expected but not received. +cc11 if the busy bit was not held for a sufficient amount of time.
*WAI	Wait to Complete.

Notes:

Appendix A
E8481A Specifications

Table 4-1. E8481A Specifications

ITEMS		SPECIFICATIONS
GENERAL CHARACTERISTICS		
Module Size/Device Type:		C-Size 1-Slot, Register based, A16, slave only, P1 and P2 Connectors
Total Channels:		Single 4x32 Matrix; or Dual 4x16 matrixes
Relays Type:		Form-A, Non-latching Reed
Typical Relay Life:	At Rated Load: [a]	1 x 10^9
Power Requirements:	Peak Module Current: Dynamic Module Current:	2.21 A @ +5 V 0.1 A @ +5 V
Watts/slot:	With 8 Crosspoints Closed: [b]	13 W
Cooling/slot:	With 8 Crosspoints Closed: [b]	0.1 mm H_2O @ 1.1 Liter/sec for 10°C rise
Operating Temperature:		0 - 55°C
Operating Humidity:		65% RH, 0 - 40°C
INPUT CHARACTERISTICS		
Maximum Voltage:	Terminal to Terminal:	42 Vdc, 30 Vac rms
Maximum Transient Impulse:		500 V peak
Maximum Current:	Per Channel (non-inductive):	0.5 A dc, 0.5 A ac peak
Maximum Power:	Per Channel (resistive load): Per Module (resistive load):	5 VA ac 40 VA ac
DC ISOLATION / PERFORMANCE		
Closed Channel Resistance:	**Per channel:**	< 2 Ω (initial)
Isolation resistance: **(between any two points, single module)**	< (40°C, 65% RH): < (25°C, 40% RH):	> 10^8 Ω > 10^9 Ω
Thermal Offset:	Per Channel:	< 50 μV

(continued on the next page)

Table 4-1. E8481A Specifications

ITEMS		SPECIFICATIONS
AC ISOLATION / PERFORMANCE (*4x32 Configuration,* ***$Z_l = Z_s$ = 50*** Ω, **< (40°C, 65% RH):*)***		
Closed Channel Capacitance:	Hi to Lo: Hi to Chassis: Lo to Chassis:	< 160 pF < 160 pF < 550 pF
Bandwidth (-3dB):	4 x 32 Configuration:	50 MHz
Crosstalk Within a Card: (Channel-Channel with 50Ω termination)	< 100 KHz: < 5 MHz: < 50 MHz:	< -65 dB < -50 dB < -27 dB
AC ISOLATION / PERFORMANCE (*Dual 4x16 Configuration,* ***$Z_l = Z_s$ = 50*** Ω, **< (40°C, 65% RH):*)***		
Closed Channel Capacitance:	Hi to Lo: Hi to Chassis: Lo to Chassis:	< 100 pF < 100 pF < 300 pF
Bandwidth (-3dB):	4 x 16 Configuration:	70 MHz
Crosstalk Within a Card: (Channel-Channel with 50Ω termination)	<100 KHz: < 5 MHz: < 50 MHz:	< -65 dB < -50 dB < -27 dB

a. 10 mA, 1 Vdc resistive load.
b. When more than 8 crosspoints are closed, add 0.34 W per crosspoint to the specified power dissipation (13 W), and 0.027 liter/sec to the air flow (1.1 Liter/sec).

Appendix B

Register-Based Programming

About This Appendix

The Agilent E8481A 4x32 2-wire Matrix Switch module is a register-based product which does not support the VXIbus word serial protocol. When a SCPI command is sent to the matrix, the instrument driver resident in the Agilent E1406A command module parses the command and programs the matrix at the register level.

Register-based programming is a series of reads and writes directly to the module registers. This increases throughput speed since it eliminates command parsing and allows the use of an embedded controller. Also, register programming provides an avenue for users to control a VXI module with an alternate VXI controller device and eliminate the need for using an E1406A command module.

This appendix contains the information you need for register-based programming. The contents include:

Register Addressing

Register addresses for register-based devices are located in the upper 25% of VXI A16 address space. Every VXI device (up to 256 devices) is allocated a 32 word (64 byte) block of addresses. Figure B-1 on page 98 shows the register address location within A16 as it might be mapped by an embedded controller. Figure B-2 on page 99 shows the location of A16 address space in the E1406A command module.

When you are reading from or writing to a register of the module, a hexadecimal or decimal register address needs to be specified. This address consists of a base address plus a register offset:

Register Address = Base Address + Register Offset

Base Address

The base address used in register-based programming depends on whether the A16 address space is outside or inside the E1406A command module.

A16 Address Space Outside the Command Module

When the E1406A command module is not part of your VXIbus system (Figure B-1), the module's base address is computed as:[1]

$$C000_h + (LADDR_h * 40_h)$$

- *or* *(decimal)*

$$49{,}152 + (LADDR * 64)$$

where $C000_h$ (49,152) is the starting location of the VXI A16 addresses, LADDR is the module's logical address, and 64 (40_h) is the number of address bytes per register-based module. For example, the module's factory set logical address is 112 (70_h). If this address is not changed, the module will have a base address of:

$$C000_h + (70_h * 40_h) = C000_h + 1C00_h = DC00_h$$

- *or* *(decimal)*

$$49{,}152 + (112 * 64) = 49{,}152 + 7168 = 56{,}320$$

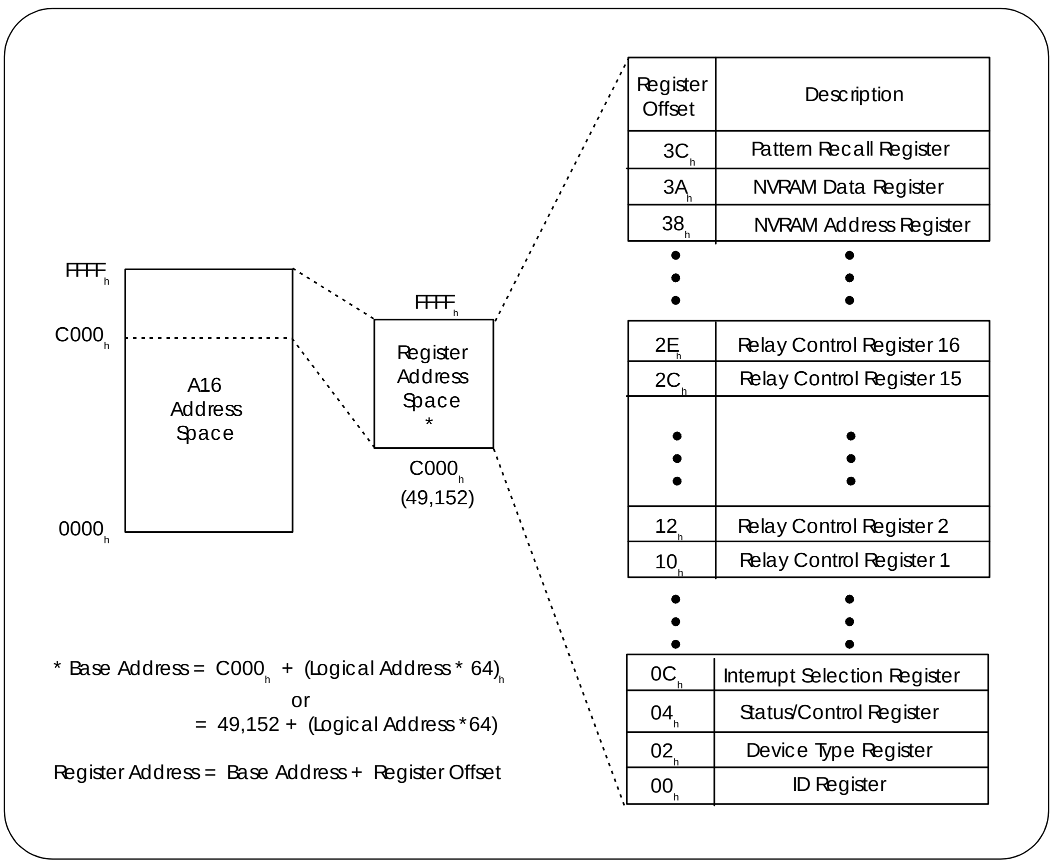


Figure B-1. Registers within A16 Address Space

1. Numbers with a subscripted "h" are in hexadecimal format. Numbers without the subscripted "h" are in decimal format.

A16 Address Space Inside the Command Module or Mainframe

When the A16 address space is inside the Agilent E1406A command module (Figure B-2), the module's base address is computed as:[1]

$$1FC000_h + (LADDR_h * 40_h)$$

***- or** (decimal)*

$$2{,}080{,}768 + (LADDR * 64)$$

where $1FC000_h$ (2,080,768) is the starting location of the register addresses, LADDR is the module's logical address, and 64 (40_h) is the number of address bytes per register-based device. Again, the module's factory set logical address is 112 (70_h). If this address is not changed, the module will have a base address of:

$$1FC000_h + (70_h * 40_h) = 1FC000_h + 1C00_h = 1FDC00_h$$

***- or** (decimal)*

$$2{,}080{,}768 + (112 * 64) = 2{,}080{,}768 + 1536 = 2{,}087{,}936$$

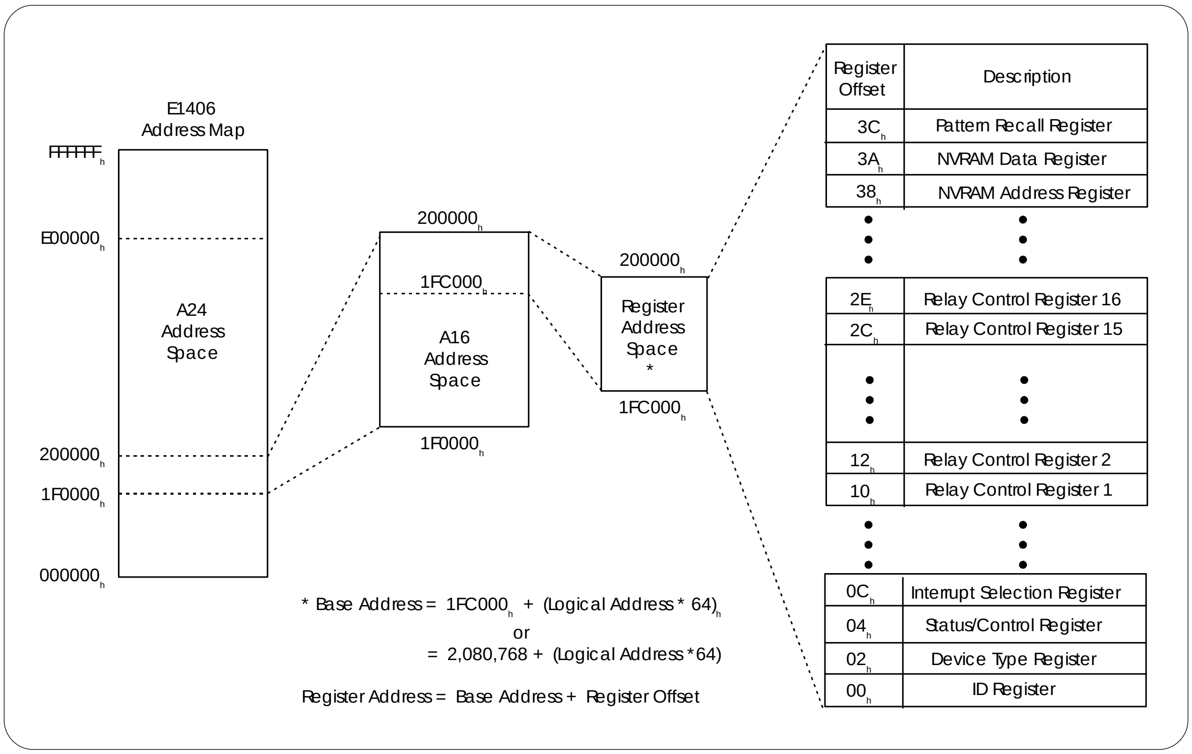


Figure B-2. Registers within Command Module's A16 Address Space

1. Numbers with a subscripted "h" are in hexadecimal format. Numbers without the subscripted "h" are in decimal format.

Register Offset

The register offset is the register's location in the block of 64 address bytes. For example, the module's Status/Control Register has an offset of 04_h. When you write a command to this register, the offset is added to the base address to form the register address:

$DC00_h + 04_h = DC04_h$
$1FDC00_h + 04_h = 1FDC04_h$

- *or* *(decimal)*

56,320 + 4 = 56,324
2,087,936 + 4 = 2,087,940

Registers Description

The E8481A Matrix Switch module contains 23 registers as shown in Table B-1. You can write to the writable (W) registers and read from the readable (R) registers. This section contains a description of the registers followed by a bit map of the registers in sequential address order.

Table B-1. Module Registers

Registers	Addr. Offset	R/W	Register Address
Manufacturer ID Register	00_h	R	base + 00_h
Device Type Register	02_h	R	base + 02_h
Status/Control Register	04_h	R/W	base + 04_h
Interrupt Selection Register	$0C_h$	R/W	base + $0C_h$
Relay Control Register (CH 0000-0007)	10_h	R/W	base + 10_h
Relay Control Register (CH 0008-0015)	12_h	R/W	base + 12_h
Relay Control Register (CH 0100-0107)	14_h	R/W	base + 14_h
Relay Control Register (CH 0108-0115)	16_h	R/W	base + 16_h
Relay Control Register (CH 0200-0207)	18_h	R/W	base + 18_h
Relay Control Register (CH 0208-0215)	$1A_h$	R/W	base + $1A_h$
Relay Control Register (CH 0300-0307)	$1C_h$	R/W	base + $1C_h$
Relay Control Register (CH 0308-0315)	$1E_h$	R/W	base + $1E_h$
Relay Control Register (CH 0016-0023)	20_h	R/W	base + 20_h
Relay Control Register (CH 0024-0031)	22_h	R/W	base + 22_h
Relay Control Register (CH 0116-0123)	24_h	R/W	base + 24_h
Relay Control Register (CH 0124-0131)	26_h	R/W	base + 26_h
Relay Control Register (CH 0216-0223)	28_h	R/W	base + 28_h
Relay Control Register (CH 0224-0231)	$2A_h$	R/W	base + $2A_h$
Relay Control Register (CH 0316-0323)	$2C_h$	R/W	base + $2C_h$
Relay Control Register (CH 0324-0331)	$2E_h$	R/W	base + $2E_h$
NVRAM Address Register	38_h	R/W	base + 38_h
NVRAM Data Register	$3A_h$	R/W	base + $3A_h$
Pattern Recall Register	$3C_h$	R/W	base + $3C_h$

NOTE *Undefined register bits (shown as "x" in the Tables) return as "1" when the register is read, and have no effect when written to.*

ID Register

The Manufacturer Identification Register is at offset address 00_h. Reading the register returns $FFFF_h$ indicating the manufacturer is Agilent Technologies and the module is an A16 register-based device.

base + 00_h	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	x															
Read	Manufacturer ID - returns $FFFF_h$ in Agilent Technologies A16 only register-based card															

Device Type Register

The Device Type Register is at offset address 02_h. Reading the register returns $02D1_h$ indicating that the device is an E8481A module.

base + 02_h	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	x															
Read	$02D1_h$															

Status/Control Register

The Status/Control Register is at offset address 04_h. It is used to control the module and inform the user of its status.

base + 04_h	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write [a]	x									IRQ E/D	x				S	Reset
Read [b]	x	MS	x						B	IRQ E/D	x		1	P	x	

a. Writing to the reserved bits ("x") will cause no action. We recommend writing "1" to these bits.

b. Reading from the reserved bits ("x") will return as "1". Do not rely on these value for card operation.

Reading the Status/Control Register

When reading the status/control register, the following bits are of importance:

- **Self-test Passed (bit 2) -** Used to inform the user of the self-test status. "1" in this field indicates the module has successfully passed its self-test, and "0" indicates that the module is either executing or has failed its self-test.

- **Interrupt Status (bit 6) -** Used to inform the user of the interrupt status. "0" indicates that the interrupt is enabled, and "1" indicates that the interrupt is disabled. The interrupt generated after a channel has been closed can be disabled.

- **Busy (bit 7) -** Used to inform the user of a busy condition. "0" indicates that the module is busy, and "1" indicates that the module is not busy. Each relay requires about 1 ms execution time during which time the module is busy.

- **Modid Select (bit 14) -** "0" in this bit indicates that the module is selected by a high state on the P2 MODID line, and "1" indicates it is not selected via the P2 MODID line.

As an example, if a read of the Status Register (base + 04_h) returns "FFBF (1111111110111111)", it indicates that the module is not busy (bit 7 = 1) and the interrupt is enabled (bit 6 = 0).

Writing to the Status/Control Register

When writing to the status/control register, the following bits are of importance:

- **Soft Reset (bit 0) -** Writing a "1" to this bit will force the module to reset (all channels open).

NOTE *When writing to the registers it is necessary to write "0" to bit 0 after the reset has been performed before any other commands can be programmed and executed. SCPI commands take care of this automatically.*

- **Sysfail Inhibit (bit 1) -** Writing a "1" to this bit will disable the module from driving the SYSFAIL line (all channels open). The Slot-0 module can detect the failed module via this line.

- **Interrupt Enable/Disable (bit 6) -** Writing a "1" to this bit will disable the module from sending an interrupt request (generated by operating relays). Writing a "0" to this bit will enable the module’s interrupt capability.

NOTE *Typically, interrupts are only disabled to "peek-poke" a module. Refer to your command module's operating manual before disabling the interrupt.*

Interrupt Selection Register

The Interrupt Selection Register is at offset address $0C_h$. It is used to set the interrupt level of the module and inform the user of the current interrupt level of the module.

base + $0C_h$	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write							x								Interrupt Level	
Read							x								Interrupt Level	

- You can set the interrupt level of the module by writing to **Interrupt Level Bits (bits 0-2)** of the register. Writing bits 2-0 with 001, 010, 011, 100, 101, 110, or 111 will set the interrupt level equal to interrupt level 1 through 7. The highest interrupt level is 7, and the lowest level is 1 (default value).

NOTE *Changing the interrupt priority level is not recommended. DO NOT change it unless specially instructed to do so. Refer to the E1406A Command Module User's Manual for more details.*

- Reading the register will return the current interrupt level of the module. The returned value 001, 010, 011, 100, 101, 110, or 111 in Bits 2-0 corresponds to interrupt level 1 through 7.

Relay Control Registers

There are sixteen relay control registers used to control the 128 channels of the matrix module. They are:

- Relay Control Register for Channels 0000-0007 (base + 10_h)
- Relay Control Register for Channels 0008-0015 (base + 12_h)
- Relay Control Register for Channels 0100-0107 (base + 14_h)
- Relay Control Register for Channels 0108-0115 (base + 16_h)
- Relay Control Register for Channels 0200-0207 (base + 18_h)
- Relay Control Register for Channels 0208-0215 (base + $1A_h$)
- Relay Control Register for Channels 0300-0307 (base + $1C_h$)
- Relay Control Register for Channels 0308-0315 (base + $1E_h$)
- Relay Control Register for Channels 0016-0023 (base + 20_h)
- Relay Control Register for Channels 0024-0031 (base + 22_h)
- Relay Control Register for Channels 0116-0123 (base + 24_h)
- Relay Control Register for Channels 0124-0131 (base + 26_h)
- Relay Control Register for Channels 0216-0223 (base + 28_h)
- Relay Control Register for Channels 0224-0231 (base + $2A_h$)
- Relay Control Register for Channels 0316-0323 (base + $2C_h$)
- Relay Control Register for Channels 0324-0331 (base + $2E_h$)

The Relay Control Registers bit definitions are listed as below:

Relay Control Register for Channels 0000 - 0007 (base + 10_h)

<table>
<tr><td>base + 10_h</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>Write</td><td colspan="2" rowspan="2">CH0007</td><td colspan="2" rowspan="2">CH0006</td><td colspan="2" rowspan="2">CH0005</td><td colspan="2" rowspan="2">CH0004</td><td colspan="2" rowspan="2">CH0000</td><td colspan="2" rowspan="2">CH0001</td><td colspan="2" rowspan="2">CH0002</td><td colspan="2" rowspan="2">CH0003</td></tr>
<tr><td>Read</td></tr>
</table>

Relay Control Register for Channels 0008 - 0015 (base + 12_h)

<table>
<tr><td>base + 12_h</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>Write</td><td colspan="2" rowspan="2">CH0015</td><td colspan="2" rowspan="2">CH0014</td><td colspan="2" rowspan="2">CH0013</td><td colspan="2" rowspan="2">CH0012</td><td colspan="2" rowspan="2">CH0011</td><td colspan="2" rowspan="2">CH0010</td><td colspan="2" rowspan="2">CH0009</td><td colspan="2" rowspan="2">CH0008</td></tr>
<tr><td>Read</td></tr>
</table>

Relay Control Register for Channels 0100 - 0107 (base + 14_h)

<table>
<tr><td>base + 14_h</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>Write</td><td colspan="2" rowspan="2">CH0107</td><td colspan="2" rowspan="2">CH0106</td><td colspan="2" rowspan="2">CH0105</td><td colspan="2" rowspan="2">CH0104</td><td colspan="2" rowspan="2">CH0100</td><td colspan="2" rowspan="2">CH0101</td><td colspan="2" rowspan="2">CH0102</td><td colspan="2" rowspan="2">CH0103</td></tr>
<tr><td>Read</td></tr>
</table>

Relay Control Register for Channels 0108 - 0115 (base + 16_h)

<table>
<tr><td>base + 16_h</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>Write</td><td colspan="2" rowspan="2">CH0115</td><td colspan="2" rowspan="2">CH0114</td><td colspan="2" rowspan="2">CH0113</td><td colspan="2" rowspan="2">CH0112</td><td colspan="2" rowspan="2">CH0111</td><td colspan="2" rowspan="2">CH0110</td><td colspan="2" rowspan="2">CH0109</td><td colspan="2" rowspan="2">CH0108</td></tr>
<tr><td>Read</td></tr>
</table>

Relay Control Register for Channels 0200 - 0207 (base + 18_h)

<table>
<tr><td>base + 18_h</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>Write</td><td colspan="2" rowspan="2">CH0207</td><td colspan="2" rowspan="2">CH0206</td><td colspan="2" rowspan="2">CH0205</td><td colspan="2" rowspan="2">CH0204</td><td colspan="2" rowspan="2">CH0200</td><td colspan="2" rowspan="2">CH0201</td><td colspan="2" rowspan="2">CH0202</td><td colspan="2" rowspan="2">CH0203</td></tr>
<tr><td>Read</td></tr>
</table>

Relay Control Register for Channels 0208 - 0215 (base + $1A_h$)

<table>
<tr><td>base + $1A_h$</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>Write</td><td colspan="2" rowspan="2">CH0215</td><td colspan="2" rowspan="2">CH0214</td><td colspan="2" rowspan="2">CH0213</td><td colspan="2" rowspan="2">CH0212</td><td colspan="2" rowspan="2">CH0211</td><td colspan="2" rowspan="2">CH0210</td><td colspan="2" rowspan="2">CH0209</td><td colspan="2" rowspan="2">CH0208</td></tr>
<tr><td>Read</td></tr>
</table>

Relay Control Register for Channels 0300 - 0307 (base + $1C_h$)

<table>
<tr><td>base + $1C_h$</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>Write</td><td colspan="2" rowspan="2">CH0307</td><td colspan="2" rowspan="2">CH0306</td><td colspan="2" rowspan="2">CH0305</td><td colspan="2" rowspan="2">CH0304</td><td colspan="2" rowspan="2">CH0300</td><td colspan="2" rowspan="2">CH0301</td><td colspan="2" rowspan="2">CH0302</td><td colspan="2" rowspan="2">CH0303</td></tr>
<tr><td>Read</td></tr>
</table>

Relay Control Register for Channels 0308 - 0315 (base + $1E_h$)

base + $1E_h$	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	CH0315		CH0314		CH0313		CH0312		CH0311		CH0310		CH0309		CH0308	
Read																

Relay Control Register for Channels 0016 - 0023 (base + 20_h)

base + 20_h	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	CH0023		CH0022		CH0021		CH0020		CH0016		CH0017		CH0018		CH0019	
Read																

Relay Control Register for Channels 0024 - 0031 (base + 22_h)

base + 22_h	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	CH0031		CH0030		CH0029		CH0028		CH0027		CH0026		CH0025		CH0024	
Read																

Relay Control Register for Channels 0116 - 0123 (base + 24_h)

base + 24_h	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	CH0123		CH0122		CH0121		CH0120		CH0116		CH0117		CH0118		CH0119	
Read																

Relay Control Register for Channels 0124 - 0131 (base + 26_h)

base + 26_h	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	CH0131		CH0130		CH0129		CH0128		CH0127		CH0126		CH0125		CH0124	
Read																

Relay Control Register for Channels 0216 - 0223 (base + 28_h)

base + 28_h	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	CH0223		CH0222		CH0221		CH0220		CH0216		CH0217		CH0218		CH0219	
Read																

Relay Control Register for Channels 0224 - 0231 (base + $2A_h$)

base + $2A_h$	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	CH0231		CH0230		CH0229		CH0228		CH0227		CH0226		CH0225		CH0224	
Read																

Relay Control Register for Channels 0316 - 0323 (base + $2C_h$)

base + $2C_h$	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write / Read	CH0323		CH0322		CH0321		CH0320		CH0316		CH0317		CH0318		CH0319	

Relay Control Register for Channels 0324 - 0331 (base + $2E_h$)

base + $2E_h$	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write / Read	CH0331		CH0330		CH0329		CH0328		CH0327		CH0326		CH0325		CH0324	

All these relay control registers are readable/writable (R/W) registers. The numbers shown in the register maps indicate the channel numbers of the module. Writing to these Relay Control Registers (base +10_h to base + $2E_h$) allows you to open or close the relay channels. Reading these registers returns the current state of the relay channels.

- Each channel uses two bits for controlling the HI and LOW relays of the channel. Writing "11" to these bits will close the related channel, and writing "00" will open the channel. Writing "01" or "10" to these bits will cause wrong operation on the related channel. For example, to close the relays on Row 0, Column 12, write "11" to bits 8 & 9 of the register (base + 12_h).

- Reading the Relay Control Registers returns a hexadecimal number. The bits that are "11" represent the related channel is closed. The bits that are "00" indicate the related channel relay is open. Reading the channel bit indicates to get the state of the relay driver circuit only. It cannot detect a defective relay.

- When power-on or reset the matrix, all the channel relays are open and when you read from these registers, all the bits are zero.

NVRAM Control Registers

There is an 8 kB non-volatile RAM (NVRAM) on the PC board of the module where up to 511 channel patterns can be stored. Each pattern includes all 128 channels state of the module requiring 16 bytes (128 bits) continuous NVRAM space to store. The bit that is "1" represents the related channel is closed. The bit that is "0" represents the related channel is open. Table B-2 lists the address space for each pattern in the NVRAM. The bits definition of each pattern is shown in Table B-3 and the numbers shown in the table indicate the corresponding channel numbers of the module.

NOTE *The pattern definition is based on the Relay Control Registers (base + 10_h to base + $2E_h$). The contents of a Relay Control Register (one word) corresponds to one byte data in a pattern.*

Table B-2. Patterns Address in NVRAM

Addresses in NVRAM	Description
0000_h - $000F_h$	For storing Pattern 0 data.
0010_h - $001F_h$	For storing Pattern 1 data.
. . .	. . .
$1FE0_h$ - $1FEF_h$	For storing Pattern 510 data.
$1FF0_h$ - $1FFE_h$	Reserved
$1FFF_h$	For storing the module configuration mode: 4x 32 matrix or two independent 4x16 matrixes.

Table B-3. Bits Map of a Pattern

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	CH0007	CH0006	CH0005	CH0004	CH0000	CH0001	CH0002	CH0003
1	CH0015	CH0014	CH0013	CH0012	CH0011	CH0010	CH0009	CH0008
2	CH0107	CH0106	CH0105	CH0104	CH0100	CH0101	CH0102	CH0103
3	CH0115	CH0114	CH0113	CH0112	CH0111	CH0110	CH0109	CH0108
4	CH0207	CH0206	CH0205	CH0204	CH0200	CH0201	CH0202	CH0203
5	CH0215	CH0214	CH0213	CH0212	CH0211	CH0210	CH0209	CH0208
6	CH0307	CH0306	CH0305	CH0304	CH0300	CH0301	CH0302	CH0303
7	CH0315	CH0314	CH0313	CH0312	CH0311	CH0310	CH0309	CH0308
8	CH0023	CH0022	CH0021	CH0020	CH0016	CH0017	CH0018	CH0019
9	CH0031	CH0030	CH0029	CH0028	CH0027	CH0026	CH0025	CH0024
10	CH0123	CH0122	CH0121	CH0120	CH0116	CH0117	CH0118	CH0119
11	CH0131	CH0130	CH0129	CH0128	CH0127	CH0126	CH0125	CH0124
12	CH0223	CH0222	CH0221	CH0220	CH0216	CH0217	CH0218	CH0219
13	CH0231	CH0230	CH0229	CH0228	CH0227	CH0226	CH0225	CH0224
14	CH0323	CH0322	CH0321	CH0320	CH0316	CH0317	CH0318	CH0319
15	CH0331	CH0330	CH0329	CH0328	CH0327	CH0326	CH0325	CH0324

There are three registers used to access the 8 kB NVRAM. They are:

- NVRAM Address Register (base + 38_h)
- NVRAM Data Register (base + $3A_h$)
- Pattern Recall Register (base + $3C_h$)

NVRAM Address Register

The NVRAM Address Register is at offset address 38_h. It is used to specify the address space in the NVRAM to be accessed. Refer to Table B-2 for the description of the addresses. This register can also be read back.

base + 38_h	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	0000 -1FFF$_h$															
Read																

NVRAM Data Register

The NVRAM Data Register is at offset address $3A_h$. It is used to set the state pattern. The data written to this register will be stored into the corresponding NVRAM location specified by the NVRAM Address Register (base + 38_h). Reading this register returns the data stored in the NVRAM location specified by the NVRAM Address Register (base + 38_h).

base + $3A_h$	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	Reserved								0 - FF$_h$							
Read																

- Before writing data to this register, make sure the address space has been set to the desired number in the NVRAM Address Register (base + 38_h). Refer to Table B-2 for more details on the addresses description.

- **Setting State Pattern:** Setting a state pattern consists of sixteen writing to this register. Also, the desired address number must be specified in the NVRAM Address Register (base + 38_h) before each data is written to the NVRAM Data Register. See Table B-3 for the bits definition of a pattern.

- **Setting Module Function Mode:** When "1FFF" is specified in the NVRAM Address Register (base + 38_h), writing a "1" to the NVRAM Data Register will set the module as an 4x32 matrix and writing a "0" will set the module as two independent 4x16 matrixes. By default, the module is configured as an 4x32 matrix.

Pattern Recall Register

The Pattern Recall Register is at offset address $3C_h$. Writing to this register is used to specify a pattern number to be recalled. The valid value is between 0 and 510. This register can also be read back.

base + $3C_h$	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	Pattern Number (0 - 510)															
Read	Pattern Number (0 - 510)															

- The recall operation consists of a series of data fetching from the specified NVRAM space, then expanding and putting these data into the corresponding Relay Control Registers. The module will set the BUSY bit of the Status/Control Register to "0" during the whole operation, and set the BUSY bit to "1" after all the relays are stable.

Appendix C
Error Messages

Table C-1 lists the error messages associated with the E8481A Matrix Switch module when programmed with SCPI commands. See the appropriate mainframe manual for a complete list of error messages.

Table C-1. Error Messages

Number	Error Message	Potential Cause(s)
-211	Trigger ignored	Trigger received when scan not enabled. Trigger received after scan complete. Trigger too fast.
-213	INIT Ignored	Attempting to execute an INIT command when a scan is already in progress.
-224	Illegal parameter value	Attempting to execute a command with a parameter not applicable to the command.
-310	System error	Too many characters in the channel list expression.
1500	External trigger source already allocated	Assigning an external trigger source to a switchbox when the trigger source has already been assigned to another switchbox.
2000	Invalid card number	Addressing a module (card) in a switchbox that is not part of the switchbox.
2001	Invalid channel number	Attempting to address a channel of a module in a switchbox that is not supported by the module (e.g., channel 99 of matrix module).
2006	Command not supported on this card	Sending a command to a module (card) in a switchbox that is unsupported by the module.
2008	Scan list not initialized	Executing an INIT command without a channel list defined.
2009	Too many channels in channel list	Attempting to address more channels than available in the switchbox.
2011	Empty channel list	Channel lists contain no valid channels.
2012	Invalid Channel Range	Invalid channel(s) specified in SCAN <*channel_list*> command. Attempting to begin scanning when no valid channel list is defined.
2600	Function not supported on this card	Sending a command to a module (card) in a switchbox that is not supported by the module or switchbox.
2601	Missing parameter	Sending a command requiring a *channel_list* without the *channel_list*.

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